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Design and Evaluation of an Energy-Dense, Light-Weight Combat Ration to Sustain Land Forces Involved in High-Intensity, Short-Duration Operations

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ABSTRACT

Many of today's military operations demand a combat ration (CR) that is smaller, lighter and more readily consumed than the current capability can deliver. DSTO-Scottsdale has developed and evaluated a prototype energy-dense, nutrient-optimised CR to sustain land forces undertaking arduous activities over a 72 hour period. A prototype pack was assembled after integrating user requirements, nutritional requirements and other design considerations. This CR was field tested at Exercise Talisman Sabre to assess user acceptability, consumption patterns and service suitability. Shelf life testing was then conducted on the commercial-of-the-shelf (COTS) food components included in the pack.

This study identified a Defence requirement for specialised CR for short-term, high-intensity operations. Army's current CR feeding systems capability will benefit from expanding the scope to deliver lighter, smaller and more readily consumed CR for specific missions of interest to Defence. To improve acceptability, consumption and nutrition of CR, more eat-on-the-move (EOTM) food components need to be included in menu design. Popular COTS food components should be considered, where relevant, as EOTM foods in CR menus.

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Design and Evaluation of an Energy-Dense, Light-Weight Combat Ration to Sustain Land Forces Involved in High-Intensity, Short-Duration Operations

Executive Summary

DSTO was tasked to develop and evaluate operationally specific combat rations (CR) as they pertain to missions of interest. To this end, a prototype energy-dense, nutrient-optimised CR was designed to sustain land forces involved in high-intensity, short-duration operations.

A number of sequential objectives were identified for successful completion of this work:

- identify specific operational user requirements
- define the nutrient composition appropriate for the specific operation
- define a serviceable delivery system
- design a ration concept
- field test the concept ration for user acceptability and consumption
- evaluate shelf life (SL).

A prototype light-weight, energy-dense (LWED) CR was designed and field tested. The design was based on the user's mission specific operational requirements, consumer needs and behaviours, and nutrient requirements. It also took into account previous DSTO research and similar ration requirements of the US Military.

The design took into account user insights into the nature and timeline of activities undertaken during operations, the need for resupply, pre- and post-operational nutritional status, appropriate pack configuration (weight, volume, water demand) and menu design (choice of components, consumption patterns and constraints). DSTO defined a number of nutrient and configuration requirements for the weight, volume, nutrient content, serviceability, quality and delivery systems.

Product selection for the 72 hour menu balanced consideration of consumer needs and wants, nutrient availability and operational constraints. Results from focus groups largely influenced the final menu design, along with the nutritional profile, packaging and anticipated SL of each food component considered.

The prototype pack achieved (if not exceeded) weight and nutrient design requirements. However, the volume requirement was not achieved. Several revisions are suggested in the body of this report to further reduce the volume of this prototype.

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The final design had no requirement for water to reconstitute food items (other than beverages) and no preparation was required to consume items other than beverages. The evening meals included in the prototype pack were palatable if consumed cold. All menu items were considered to have high organoleptic acceptability.

The provisioning of eat-on-the-move food items likely influenced higher consumption rates.

There was a general liking for most items in an operational environment. With the exception of the chocolate flavoured gel and ration chocolate, all items had over 50% support in the 'like' direction. Attitudes towards serve size varied, however consensus was that no product was supplied in excess. There was a general high consumption rate for food items. Gels and beverages (sports drink, coffee and tea) were the least consumed, being most frequently partially consumed.

Ration discard rates, although less than for previous studies of CR consumption in the field, were still high and further improvements are required to increase consumption when/if reduced-energy CR are to be the basis of rationing in the short term.

The average energy consumed per day was 6487 kJ. This was 78.5% of the 8260 kJ provided, and was less than the target of at least 90% consumption. The effect of this on cognitive and physical performance is unknown and was outside the scope of this study. Sugar was the least consumed energy source. An over-supply of sweet products may have contributed to the unexpectedly low total energy consumption. Future improvements may include increasing savoury carbohydrates and decreasing sweet food items. This may improve overall energy consumption.

Protein consumption (81%) was reasonably close to the target value of 90% and absolute consumption (~57 g/day) surpassed the initial design target (>50 g). Personnel frequently reported feeling hungry at the conclusion of the 72 hour period, suggesting that protein intake may not have been sufficient to achieve adequate satiety.

Commercial-off-the-shelf (COTS) gels and chocolate drink were found to meet SL requirements. Banana chips (in military packaging) were also suitable, however the cost of the packaging was considered prohibitive for inclusion of this product in CR. Several other COTS products and bulk supply food products showed potential for inclusion in CR when re-packaged in military packaging.

DSTO recommends that Army, as the capability manager, consider integrating the findings from this study into the current user requirement for CR to expand the scope, functionality, capability and operational requirements for future CR.

COTS items, with brand familiarity and high acceptance ratings, should be more widely used to improve overall nutrient intake and deliver essential nutrients.

It is further recommended that Army collaborate with DSTO and other stakeholders to review, refine, justify and document the future capability and operational SL requirements for CR.

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As a result of this study, a number of potential improvements have been identified for the design, configuration and SL requirements of the LWED CR concept. Further research into design and evaluation of a LWED CR is required to investigate the effect of reduced nutrient intake on performance over the intended period of consumption. Work is also required to define requirements for micronutrients in a LWED CR and to further evaluate the adequacy of this ration concept to meet those requirements.

It is recommended that DSTO be tasked to further investigate improvements to the functionality and performance of the prototype LWED CR.

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Tracey graduated from La Trobe University with a B.App.Sc. (Honours). Since joining DSTO in 1994 she has worked at the bench in food chemistry, food microbiology, sensory evaluation and food technology laboratories (for food and packaging T&E). Tracey has contributed to the development and evaluation of various current and prototype ration packs, investigating the nutritional content, product compliance and user acceptability.

Her current role is to investigate food science and technology aspects of Defence rationing systems. In particular, setting and reviewing specifications and standards for food and packaging, quality assurance of food and packaging and logistics of combat ration packs and their components to enhance military performance of ADF members while in training and on operations.

Tracey's current research interests include investigating the design requirements (strategic, capability and operational) for current and future military ration packs and optimising the supply chain management systems to support the safety, quality and shelf life of combat rations.

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Acronyms

ADF	Australian Defence Force
ADHREC	Australian Defence Human Research Ethics Committee
ANOVA	analysis of variance
AQL	acceptance quality level
ASLT	accelerated shelf life testing
BBQ	barbeque
CARP	combat assault ration pack
CHO	carbohydrate
CMNR	Committee on Military Nutrition Research
COTS	commercial-off-the-shelf
CR	combat rations
CRP	combat ration pack
CR1M	combat ration one man
CRC	client requirement code
DSTO	Defence Science and Technology Organisation
EOTM	eat-on-the-move
ESB	electrolyte sports drink
FD	freeze dried
FSR	first strike ration
GI	glycaemic index
HPFC	hard panned fruit confectionery
IOM	Institute of Medicine
LWED	light weight, energy dense
MOTS	military-off-the-shelf
NEB	non-enzymatic browning
95% CI	ninety-five percent confidence level
NIP	nutrition information panels
PR1M	patrol ration one man
R&D	research and development
SD	standard deviation
SL	shelf life
SPC	soft panned confectionery
S&T	science and technology
3RAR	Third Battalion Royal Australian Regiment

1. Introduction

The battlefield of today is significantly different to the one current combat rations (CR) were designed for. There is increasing demand to balance load carriage with the ability to perform intended operational roles. The most recent *Defence White Paper* (Department of Defence, 2013) states that 'Principal Task One for the ADF remains the self-reliant defence of Australia against armed attack.' To achieve this, soldiers will be required to be more mobile and operate as part of smaller, more agile units. As such, it has never been more crucial for Defence personnel to reduce the weight of mission-critical systems and equipment as well as sustainment items.

Client Requirement Code (CRC) L05/0210 'Weight reduction of rations and water' requires science and technology (S&T) activities to deliver new CR, with the aim of reducing soldiers' load carriage.¹ Research and development (R&D) towards achieving this might include:

- examination of CR systems for light infantry and special forces from other nations
- development of light-weight, energy-dense patrol rations to sustain personnel for limited periods
- provision of advice on the trade-off between bulky ration carriage and reduced ration content and how this might impact on operational performance.

The current User Requirement for CR does not specify a need for reduced-weight, nutrient-optimised CR (Army Headquarters, 2009). However, it is apparent that specialised CR are required to achieve reduced load carriage, taking into consideration environmental influences on product quality and consumption rates, and the requirement to provide adequate energy, macronutrients and micronutrients.

1.1 Current combat ration designs

The current rationing system provides ADF personnel with nutritional sustainment in the form of fresh and combat rations (Department of Defence, 2009). CR are used in training and operational environments when fresh or canned equivalent or cooking facilities are not available. CR are divided into two groups: Emergency CR intended for consumption in emergency situations or when extenuating circumstances warrant their use, and combat ration packs (CRP).

CRP are designed to satisfy the nutritional requirements of ADF personnel (Army Headquarters, 2009). The present one-man ration packs are the patrol ration one man (PR1M) and the combat ration one man (CR1M). The major difference between the packs is that the PR1M is considerably lighter than the CR1M while still providing similar nutrition (McLaughlin *et al*, 2002; Department of Defence, 2009).

¹ Other CRC's likely to benefit from this work include; L12 05/0520 General Support – Catering CR, LOG 08/0002 Develop ADF CR for future requirements, CDF 11/0008 Develop ADF CR for future requirements.

The CR1M is the general purpose CRP, so is the one most commonly used to feed ADF members. It provides sustenance over a 24 hour period and weighs approximately 1.9 kg. Each of the eight menus (designated A-H) consists of two main courses, snacks and a number of sundry items, including some that are common to all menus. The ration is nutritionally balanced, and provides ~19 000 kJ (Bui, McLaughlin and Coad, 2014). This is more than the 16 000 kJ recommended by Forbes-Ewan (2009) for general purpose combat rations.

The PR1M is the special purpose CRP and is used predominantly by Special Forces. It is produced in small numbers but has an important role for the long range patrol activities of the ADF. Extra water is required to re-hydrate the freeze-dried and other dehydrated components. The PR1M provides sustenance over a 24 hour period and weighs approximately 1.0 kg. Each menu consists of two main courses of freeze-dried (FD) meals, snacks and a number of sundry items. There are five menus (A-E), which offer a variety of main courses and snack items, and also contain several items in common. The ration is nutritionally balanced, and provides ~18 600 kJ (Bui, McLaughlin and Coad, 2014).

CRP designs have a number of drivers and constraints (problems, issues, challenges) related to the food, the consumer and the operational environment. Research indicates that ADF members do not consume CRP in their entirety, often discarding many items (Forbes-Ewan, 1988; Booth *et al*, 2001; Forbes-Ewan, 2001; Carins, 2002). The problem of food discarding when rationing is by CRP appears to be universal among allied nations (NATO, 2010). Factors known to influence discard rate include load carriage, food preferences, menu boredom/fatigue and climatic influences (on food palatability and personnel mood). Soldiers are continually forced to choose between satisfying nutritional requirements, the need for water, protective clothing, ammunition and other load carriage considerations. As a result, ration under-consumption appears to be almost inevitable when rationing is with CRP that must be carried by troops.

1.2 Previous DSTO R&D on light-weight rations

In 1998 DSTO recommended that the potential value of a light-weight 'assault' ration be investigated to alleviate many of the issues faced by military personnel (Stephenson *et al*, 1998). Concern was expressed over the potential for adverse effects on military performance of a negative energy balance resulting from the practice of discarding items. Soldiers indicated substantial culling of components and replacement with commercially available items (commonly known as 'jack rations'). These researchers concluded that nutrient consumption of soldiers was unknown to Defence, given the levels of ration culling and exchange, and the widespread use of jack rations.

In 1998, DSTO proposed a 'Combat Assault Ration Pack' (CARP) for use by the ADF. The recommended criteria for the design of the CARP (Forbes-Ewan, 2000) included:

- total weight of food \leq 550 g
- total weight of pack \leq 600 g
- no water required to reconstitute food items (except beverages)

- provide ≥ 300 g of carbohydrate (CHO), the preferred fuel for muscular work
- total energy ≥ 8000 kJ
- no preparation required (except for reconstituting beverages)
- components must have high organoleptic acceptability.

This design was proposed for trial at Exercise Phoenix in late 1998; however, the trial did not proceed.

In 2001 DSTO evaluated a PR1M trial pack developed by Support Group Army (McLaughlin and Thomson, 2002). The PR1M trial pack was a hybrid between the PR1M and CR1M, with each menu including one FD meal and one retort pouch. A number of other product inclusions were novel and/or reformulations of current CR items. The nutrient profile and nutrient intakes were not documented for this ration design. Rather, the study sought to understand user acceptability, adequacy of the amount provided, discard rate and ease of use of this ration concept. A majority of ADF personnel ($n=307$) from four units—2nd Force Support Battalion, 3rd Battalion Royal Australian Regiment, 1 Commando Regiment and 4th Battalion Royal Australian Regiment—preferred the hybrid over the CR1M or PR1M, particularly the combination of one FD and one retort pouch meal.

1.3 US Military rations for short-term, high-intensity combat operations

Under the auspices of the Standing Committee on Military Nutrition Research (CMNR) within the Institute of Medicine (IOM), the committee on 'Optimisation of nutrient composition of military rations for short-term, high stress situations' investigated and reported on nutrient composition for short-term, high-intensity combat operations (IOM, 2006). This committee was appointed at the request of the US Department of Defense, who sought guidance on nutritional composition for design of rations for sustained operations. The committee recommended the following nutrient composition for such rations:

- energy intake: 11 715 kJ including 1675 kJ from carbohydrate supplements such as candy, gels and sports drink powder
- protein: 100–120 g
- carbohydrate: 450 g (including 100 g from carbohydrate supplements)
- fibre: 15–17 g
- fat: 58–63 g (22–25% of energy)
- vitamins: A, B₁, B₂, B₃, B₆, C, D, E folate (at specified levels)
- minerals: Ca, Cu, I, Fe, Mg, P, K, Se, Na, Zn (at specified levels)
- caffeine: 100–600 mg.

This nutritional composition was based on the following assumptions:

- providing a ration with a minimum energy content of 10 000 kJ would be appropriate for the short-term (repeated periods of 3–7 days up to one month)
- inclusion of a further 1675 kJ in the form of beverage powder supplements, gels and fruit-flavoured candies was considered beneficial
- macronutrients and micronutrients would be equally distributed among all food items to minimise nutrient deficiencies in the event that some items were discarded
- micronutrient levels recommended were those appropriate for an expected energy expenditure of 18 830 kJ to ensure metabolic efficiency (IOM, 2006).

The guidelines provided by the IOM were not constrained by load carriage considerations. However, they were very useful and relevant in the design of the (US) first strike ration (FSR).

1.3.1 First strike ration

The FSR is the only reduced-energy assault ration in service for highly mobile US soldiers. Its purpose is to optimise soldier cognitive and physical performance by enhancing nutritional status and metabolic fuel availability during high-intensity missions, while minimizing ration weight/volume, food wastage and source material. It is compact, light-weight, energy-dense, contains foods that are familiar to troops, and supports mobility through provision of many eat-on-the-move (EOTM) components.² EOTM components support on-demand nutrient delivery systems.

The FSR has application in high-intensity conflict and is specifically designed for consumption during the first 72 hours of a combat mission. The initial design elements of this purpose specific ration included (Koenig, 2006):

- total weight of 1.27 kg
- total volume of ~3960 cm³
- total energy ~12 500 kJ
- 360 g of CHO
- 110 g of protein

² <http://nsrdec.natick.army.mil/media/fact/food/FSR.pdf>



Figure 1 United States Department of Defense first strike ration (FSR)

Food items included a breakfast meal (bagel, pocket bread or sandwich), biscuits and spread, sports drinks, HooAH! Bars, jerky, trail mix, gum, confectionery, brew kit and sundries.

1.4 Aim of this study

Under Task ARM 04/144 DSTO was requested to develop and evaluate operationally specific CR as they pertain to missions of interest.³ More specifically, the task was to develop an energy-dense, nutrient-optimised, low-weight/ volume CR aimed at sustaining land forces involved in high-intensity, short-duration operations.⁴

A number of sequential objectives were identified for successful completion of this work:

- identify specific operational user requirements
- define the nutrient composition appropriate for the specific operation
- define a serviceable delivery system
- design a ration concept
- field test the concept ration for user acceptability and consumption
- evaluate shelf life (SL).

³ Tasking continued under TASK ARM 06/129 *Innovative Technologies for Dynamic Rationing*, TASK DCDS 07/082 *Optimising ADF Performance through Nutrition* and concluded under Task 07/078.

⁴ While it was understood the requirement was for 'no significant decrements in physical fitness or cognitive performance resultant from sustainment on a reduced nutritional content CR', this fell outside the scope of this study and was not evaluated.

2. Materials and Methods

The design and build of the prototype used qualitative research methods, while the acceptability, consumption and SL measures were quantitative.

2.1 Establishing user requirements

The LAND 125 Soldier Modernisation group, whose focus was to identify and articulate the requirements for the ADF future soldier, was engaged to facilitate direct liaison with potential users. The Third Battalion Royal Australian Regiment (3RAR), based at Holdsworthy Barracks, Sydney, was identified as a suitable user group and was engaged for the duration of this study. User input was sought to understand concerns, constraints and considerations with respect to current CR and to evaluate new food concepts, e.g. relevant developments in food technology and commercial-off-the-shelf (COTS) items.

Interviews and focus groups were conducted with members of 3RAR, a substantial consumer of CR. Their knowledge and understanding of the appropriateness and faults of current ration items was deemed vital to the development of the prototype CR.

2.1.1 Interviews with user representatives

DSTO sought information from the 3RAR Commanding Officer and Executive Officer on the following variables to further scope the operational requirements for the energy-dense, nutrient-optimised, low-weight/volume CR:

1. likely operational scenario/tempo (activities and timespan)
 - a. intensity (low, medium, high)
 - b. distance covered
 - c. load carriage
 - d. sleep/rest patterns
2. likely duration of operations to be supported by the proposed CR
3. geographical factors (including altitude and terrain)
4. effects of different climates
5. psychology of users
6. requirement for advice on a pre-deployment meal
7. requirement for post-deployment nutritional recovery
8. resupply considerations/constraints over the intended period of consumption, storage, handling, distribution, frequency
9. signature management, including waste and release of food aromas
10. requirement for a 'low residue' ration (to minimise bowel activity)

11. pack configuration (weight, volume, water demand)
12. menu design – component selection and variety
13. mobility considerations including EOTM
 - a. should the design facilitate a combination of sit-down and on-the-go consumption patterns or focus on one?
 - b. are there operational periods where mobility has greater influence on consumption level?
14. food presentation/preparation/service suitability
 - a. what opportunity is there to prepare meals and beverages?
 - if meals can be prepared, is water availability likely to be limiting (i.e. what is the scope for FD main meals, dried pasta/rice, and so on)?
 - should the ration be capable of being eaten (i.e. at least moderately acceptable) cold
 - satiety considerations
15. allergen management considerations (tolerance of ingredients)
16. importance of micronutrients (limitations when using COTS).

2.1.2 Focus groups with consumers

Focus groups⁵ were used to:

1. identify and evaluate new product concepts leading to improved food consumption
2. research audience reactions, expectations, attitudes and interests in product concepts and their variety
3. uncover what issues really matter to the audience regarding food provision and intake specific to an energy-dense, nutrient-optimised, low-weight/volume CR design
4. identify current CR components that may be useful inclusions in the concept ration.

In total, nine focus group sessions were conducted over four visits to 3RAR. Each group comprised 16–20 personnel, divided into two sub-groups. A total of 90 minutes was allocated to each discussion and audio records were retained. Effort was made to separate the more senior personnel from the less experienced (and generally younger) soldiers, to allow investigation of potential age-related differences in food preferences. Varying degrees of prior exposure and use of CR in operational scenarios, as well as potential for ‘group think’ were also likely to influence the outputs delivered from the two demographic sub-groups.

⁵ Focus groups were qualitative, taking the form of in-depth discussions with small numbers (8–10 soldiers).

Initial discussions were of a general nature—individual soldiers were asked to outline their likes and dislikes among ration pack components, their current usage patterns of jack rations and ideas on alternative food choices.

In-depth discussions then focused on assessing the acceptability and service suitability of proposed products in an energy-dense, nutrient-optimised, low weight/volume CR concept ration. Initially the visual, tactile and aural attributes of products—both within and separated from packaging—were discussed. Consumer representatives then tasted and discussed each product in terms of appearance, texture and flavour. Packaging, serve size, palatability in different environments, effects on morale, ease of consumption, preparation considerations (reconstitution and heating) and acceptability were also discussed.

For each product, soldiers were asked whether they would consume the product if it was included in a purpose designed CR. Products were defined as suitable for further consideration where $\geq 75\%$ of respondents replied 'yes'.

Concepts evaluated included:

- bars high in protein and/or CHO
- confectionery
- FD and dehydrated fruits
- nuts
- dried and processed meats
- sport/energy gels
- processed fish
- bread
- protein-based drink powders.

Appendix A details products considered by the focus groups. Depending on the quantity and urgency of requirement, products were sourced from manufacturers or suppliers directly, or from a local supermarket.

2.2 Nutritional requirements, delivery system and menu design

Energy and macronutrient requirements were determined through:

1. identifying current CR nutrient recommendations (Forbes-Ewan, 2009)
2. investigating the nutrient recommendations and composition of other military rations designed for short-term, high-intensity combat operations (IOM, 2006; Askew et al., 1987; Keonig, 2006)
3. considering previous DSTO R&D in designing light-weight CR concepts (Forbes-Ewan, 2000; McLaughlin and Thomson, 2002).

Configuration and menu design considerations included:

1. minimising weight and volume
2. targeting items with high organoleptic acceptability
3. rationalising non-food items
4. optimising serve size (portion) and variety
5. consolidating multiple portions (upsizing) foods packaged in tubes (given the re-sealability functionality of packaging)
6. maximising the opportunity to include COTS food items.

2.3 Field testing for user acceptability, consumption and service suitability

Ethical clearance for this project was provided by the Australian Defence Human Research Ethics Committee (ADHREC Protocol 486/07).

2.3.1 Participants

Trial participants were soldiers from 3RAR, engaged in an airborne insertion and subsequent operational activities for 72 hours during Exercise Talisman Sabre.

DSTO requested the support of 200 ADF personnel. Consumer acceptability studies typically require a minimum of 70 individual responses for statistical validity (Carpenter et al, 2000). Indications from 3RAR were that 150 personnel would be available as potential participants in this study.

2.3.2 Design

The treatment was a three-day supply of rations presented as a single ration pack. These were issued to each soldier prior to the commencement of the exercise. Soldiers were briefed on the intended consumption pattern, i.e. order of consumption and designated day for the consumption of each product. This was reiterated in the menu sheet provided. Participants were requested to keep all food packaging and uneaten items, and were asked not to exchange ration items with other participants. No jack rations were allowed during the trial (this was strictly monitored by military staff).

A pre-trial briefing was held to inform participants of the voluntary nature of this study. Potential participants were screened for known allergies and intolerances and provided with a background on the intent of the study. Completed consent forms were collected from those who provided informed consent to participate. Subsequent to a 24 h cooling off period, participants were issued with the CR. This was issued prior to deployment, as the activity commenced with an air insertion from a Hercules aircraft.

On completion of the consumption period a 5-page questionnaire (Appendix B) was administered in the field and each individual's waste (all packaging and non-consumed food items) was collected.

Acceptability of CR components was determined using a 5-point Likert scale (1=hate it, 2=dislike it, 3=no opinion, 4=like it, 5=love it). For each item that was not liked, participants were requested to indicate how it could be improved.

Service suitability was determined through quantitative questioning related to mobility (ease of use and delivery systems), pack configuration, signature management, water consumption and menu design. Finally, qualitative questioning investigated the suitability of preparation processes and clean-up.

Suitability of serving size was evaluated using a 3-point scale (1=too much, 2=enough, 3=not enough). Waste data was compared with serve size response for each individual. The percentage consumption of each item was categorised as *not consumed*, *partially (50%) consumed* or *consumed* using food discard data from packaging and waste collection.⁶

2.3.3 Statistical data analysis

SPSS Statistics 21⁷ was used to generate descriptive statistics as a measure of central tendency for all numeric data sets captured by the questionnaire. Means, standard deviations (SD), standard errors of means and 95% confidence intervals (95% CI) were calculated. Outliers were assessed by inspection of box plots for values greater than 1.5 box-lengths from the edge of the box. Extreme outliers were those identified to be greater than 3 box-lengths away. The Shapiro-Wilk test was applied to each data set to test normality.

A one-sample t-test was run to determine whether the scores assigned for acceptability, adequacy and percentage consumption were different to the targets, which were:

- acceptability rating of 3 (with results above this value being designated *favourable* and those below *unfavourable*)
- adequate provision rating of 2 (with results significantly above or below this target being designated *unfavourable*)
- consumption score of 90% (with results above this percentage being designated *favourable* and those below *unfavourable*).

The t-statistic was evaluated at the 5% significance level. If the test result was found to be significantly different to, and on the 'wrong' side of the test criterion, the result was designated as *not achieved*. If the test result was significantly different to, and on the 'right' side of the test criterion, the result was designated as *achieved*. If the test result was not

⁶ Where no packaging was presented, a 'no response' was reported. DSTO have also assumed that the content of the brew kit was equally consumed over the three days of the trial.

⁷ Licensed material. 2012, SPSS Inc, an IBM Company.

significantly different to the test criterion the result was also designated as *achieved*.⁸ Data sets that did not display normal distribution were analysed by the Wilcoxon signed rank test – a non-parametric test – in addition to the t-test.

2.4 Shelf life evaluation

Food items chosen for inclusion in the prototype menu were subjected to SL trials in real-time and accelerated SL testing (ASLT).⁹ The goal was to evaluate the ‘time-to-failure’ of each component when stored at a range of temperatures – 20, 30, 37, 48 and 55 °C – for a specified period of time. Storage temperatures chosen were those used by DSTO for ASLT, with the addition of 55 °C as an extreme of likely storage conditions.¹⁰

2.4.1 Samples

All products were procured from wholesalers or commercial retailers, and were therefore subjected to typical distribution conditions prior to controlled storage trials. The amounts of each product required for sensory evaluation were calculated based on the number of storage conditions, frequency of testing and provision of sufficient portion size. Bulk supply products were repackaged in military packaging.¹¹ Appendix C details the manufacturers/suppliers, product batch codes, storage conditions and packaging materials.

2.4.2 Storage profile

A number of profiles were employed for SL studies (Appendix C, Table C1). The choice of profile depended on the amount of sample available and the anticipated rate of deterioration under these conditions. Consideration was given to potential safety risks and quality-limiting characteristics (primary modes of deterioration) in selecting the appropriate storage profile. Appendix C, Table C2 details the storage profile employed for each food item evaluated.

As products were removed from storage they were refrigerated (1 °C) to prevent further changes prior to testing. Sample profiles were pooled to compare product quality in grouped evaluations.

2.4.3 Sensory evaluation

Evaluation and interpretation of SL was based solely on sensory evaluation of food products. A 9-point Hedonic Rating Test was used to assess acceptability on a quantitative

⁸ The one-sample t-test is a fairly robust test to deviations from normality. That said, where a violation occurred, it was reported.

⁹ Current CR items were exempt as they had already been assessed for SL. Current CR components included in the prototype pack were ration chocolate, sports electrolyte drink powders, BBQ chicken, tuna with dried tomato, cracker biscuits, sweet chilli sauce, chilli con carne, brew kit and ancillary items.

¹⁰ This profile is also typically employed to evaluate potential growth of thermophilic organisms in canned foods.

¹¹ Typically with a laminate material of 12 µm polyester/12 µm metallised polyester/25 µm Surlyn.

response scale with interval properties for attributes of appearance, texture, flavour and overall acceptability. The scale was labelled in hedonic terms (1=extremely poor to 9=excellent, with 5=neutral). This 9-Point Hedonic Rating is an internationally recognised test method (Chambers and Baker Wolf, 1996; Standards Australia, 2007). Samples were presented to panellists (n=8–10) in a prescribed (balanced) order of presentation according to William's Design (Compusense Inc., Sensory Evaluation Software, 2008). Samples were presented over four sessions. Sessions 2–4 included a 'blind' control. Panellists for all sensory evaluations were DSTO staff members.¹²

Acceptability criteria for sensory evaluation were provided by the Defence Materiel Organisation (Warrant Officer Class 1 Noel Hallett, Supply Support (Inspector Foodstuffs) Joint Logistics Command, pers. comm.).¹³ A Hedonic Rating of 5 was designated as the minimum acceptable quality level (AQL) –a result of less than 5 for any descriptive quality parameter meant that the product was *unacceptable*. The time taken for a mean result of less than 5 to be achieved is designated the time to failure for that food at each of the five storage temperatures.

2.4.4 Statistical data analysis

SPSS Statistics 19¹⁴ was used to generate descriptive statistics as a measure of central tendency and presented as mean, median, minimum, maximum, 95% confidence interval (95% CI). Independent one-sample t-test was applied to test the null hypothesis that the population mean was equal to the acceptability value. The t-statistic was evaluated at the 5% significance level. If the test result was found to be significantly different to, and on the 'wrong' side of, the test criterion, the designated result was *fail*. If the test result was significantly different to, and on the 'right' side of, the test criterion, the designated result was *pass*. If the test result was not significantly different to the test criterion the designated result was *pass*.

One way analysis of variance (ANOVA) was applied to all data groups for each sensory (quality) parameter to identify significant differences ($p < 0.05$) between storage profile sampling points. Multiple comparison tests—Tukey's HSD—were applied post hoc to further evaluate the data.

¹² In-house panels cannot replicate and/or evaluate consumer acceptability when influences from operational environment, physical and mental state of consumers, packaging and necessary preparation cannot be assessed. They are however, useful to identify quality changes and the degree of change likely for each product over the storage profile.

¹³ DMO and DSTO have historically used these criteria, however they have not yet been formalised.

¹⁴ Licensed material. 2010, SPSS Inc, an IBM Company.

3. Results and Discussion

3.1 Designing the ration concept

The design of the prototype light-weight, energy-dense (LWED) CR culminated from understanding the user's mission-specific operational requirements (such as configuration, load carriage and nutrition for optimal performance), consumer needs (service suitability) and behaviours (acceptance and consumption), nutrient requirements and reflecting on previous DSTO research and similar ration requirements of the US Military.

3.1.1 Guidance from user representatives

User representatives of 3RAR provided valuable insight into the nature and timeline of activities undertaken by ADF personnel for an air insertion and assault mission. Discussions identified the following considerations as being relevant:

- the type of military operation
- the period before resupply
- consumption of a pre-deployment meal¹⁵
- signature management
- pack configuration (weight, volume, water demand)
- menu design (choice of components, consumption patterns and constraints)

Satiety was initially assumed to be an important consideration, but this was not confirmed during discussion. Personnel train themselves to manage 'feeling hungry'. However, users have a strong desire to seek reassurance that the required nutrition was being provided by the feeding system (or systems).

User representatives explained that a typical military operation for the unit usually began with a flight of about six hours. During the flight, personnel were fully laden with their weapon, backpack and other essential equipment for the operation. Every effort was made to stay upright, to lessen the effects on individuals of rolling and pitching of the aircraft. Typically, no food and only minimal water was consumed during the flight.

A high incidence of air-sickness was typically experienced. Many expelled their pre-flight meal and therefore parachuted with an empty stomach. Personnel released a lot of adrenaline during the jump. Approximately three hours after landing and commencing patrolling, personnel were likely to 'hit-the-wall', i.e. energy levels were substantially diminished. The ground assault offered little opportunity for rest. Soldiers covered long distances on foot with high load carriage.

¹⁵ The idea of a pre-parachute supplement that would aid in reducing the incidence of air sickness should be considered. Air sickness management through tablets or a ginger supplement, administered early to ensure digestion, may be appropriate.

Units typically carried sustainment for a 72 hour period, with resupply or fresh feeding then available. Therefore, a 72 hour menu was regarded as appropriate for this prototype light-weight combat ration. However, periods of up to five days may be endured for covert operations. Signature management considerations, including food waste and packaging, were considered important. The current CR1M was criticised for the many layers of packaging.

No decisive limitations on pack configuration were provided by user representatives. They could only conceptualise their requirement as 'be as light as possible while ensuring nutritional requirements were delivered' and stated that 'it would be great if personnel could carry a day's rations in the pocket of their cams (camouflage uniform)'.

User representatives thought it appropriate that menu design considered the following:

- ADF personnel would carry 8 L of water per day where no re-supply was expected, and 4 L per day where re-supply was expected 12 hours after commencement
- negligible benefit was evident in the use of FD meals rather than retort meals, when extra water carriage was required to re-hydrate FD meals prior to consumption
- EOTM consumption should be relied on for the majority of nutrient intake, with no preparation (other than rehydration of beverages) and ideally consumed directly from the packaging
- an evening meal should be included, one that may have some (minimal) requirement for preparation, and it should be palatable cold
- allergen management was not considered necessary, because recruitment to the ADF involves screening for allergies.

A number of other potential considerations were discussed and exempted from further consideration in the design. These were:

- locality and environmental conditions of operations
 - the locality and environmental conditions were identified as many and varied, and no consideration of the design factors could be inferred or applied
- post-deployment recovery management
 - this requirement could not readily be defined due to the many and varied operational scenarios, so it did not receive further consideration
- requirement for a 'low residue' ration (to minimise bowel activity) was not seen as a high priority issue; however, operations in an urban environment would benefit from reduced bowel function.

Provision of advice on a pre-deployment meal, while appropriate to ensure optimal performance of ADF personnel involved in air insertion operations, was considered to fall

outside the scope of this research. However, DSTO strongly recommends that Defence provides due consideration to this requirement.

3.1.2 Nutritional requirements, load carriage and service suitability considerations

A number of assumptions and guidelines were made by DSTO with regard to the design requirements:

1. micronutrient requirements would not constrain the menu design
2. consumers had been on a period of fresh feeding prior to consumption of this ration, are physically fit, healthy and have no nutrient deficiencies
3. soldiers had access to water for both hydration and beverage preparation
4. subsistence on the energy-dense, nutrient-optimised, low weight/volume CR was to be directly supported by fresh feeding systems.

Typical consumption rate for the CR1M (a ration that in 2002 provided ~15 000 kJ) is reported to be ~60% (Forbes-Ewan, 1988; Forbes-Ewan, 2001; Carins, 2002). Therefore, DSTO anticipated that providing a CR of 9000 kJ, if fully consumed, would lead to similar total energy intake as applies to the CR1M.

Forbes-Ewan (2009) reported that physical performance would be preserved during several days of underfeeding, provided sufficient CHO and minerals are consumed to minimise the diuresis associated with semi-starvation diets and adequate CHO is available to support metabolism during prolonged work. Even with daily energy expenditure as high as 25 000 kJ/day for some Special Forces activities, it is unlikely that any substantial detriment to performance (resultant from the negative energy balance) would be observed over a 72 hour period (Tharion et al 2005; IOM, 2006; Forbes-Ewan, 2009). The effects of geography, climate, stress and sleep deprivation are all likely to be detrimental to performance, however they have not been considered here in establishing the nutritional requirements, because their effects could not be readily articulated by the user, so they were considered to be out of the scope of this concept design.

Consequently, a target of 9 000 kJ per day was set as the criterion for energy for the LWED CRP.

Care should be taken to ensure that a reduced-energy ration still provides adequate CHO. This is because adequate CHO is of greater significance to physical performance than the provision of adequate total energy (Forbes-Ewan, 2009). CHO is the preferred fuel for both hard physical work and for cognitive performance and should provide $\geq 60\%$ of the total energy intake.

While protein was not considered important for satiety (one of the important functions protein carries out), it was considered important for muscle repair. The criterion for protein was set at 12–15% of total energy (63–79 g of protein), with fat supplying the remainder.

Maintaining a reasonable amount of fat in the ration was considered appropriate to provide a readily digestible source of high-density energy. Fat is also known to improve the palatability of foods and by optimising its content in food items would likely improve consumption. Approximately 25% of energy from fat was considered a reasonable compromise that allowed maximising carbohydrate availability while also maintaining adequate acceptability.

In summary, the macronutrient distribution ratio (ratio of contribution of protein, carbohydrate and fat respectively to total energy) was set at 12-15:60-63:25 for the LWED CR concept menu.

Focus was placed on ensuring that each food component chosen was nutrient-dense. Energy densification was anticipated to facilitate greater nutrient intake, given soldiers were more likely to carry adequate provisions when delivered in lower weight and volume. The moisture content of individual items was known to vary and products high in moisture did little to support ensuring products were energy-dense. Most items chosen for inclusion would likely be of intermediate moisture content (~10-20%). However, to ensure adequate acceptability, main meals contained 60-80% moisture.

To minimise load carriage, and given the user was not able to quantify performance requirements for this parameter, DSTO imposed design constraints for weight and volume. The total ration weight needed to take account of non-food items (sundries including spoon, toilet paper, matches, etc.) and packaging. A target of 140 g per day was set. Moisture (in food) was anticipated to be ~160 g per day. Adding these weights to that identified as the likely contribution from food (CHO 350 g, protein 50 g, fat 50 g, other 50 g), a total weight target of 800 g/day was set. Rationalisation of non-food items such as matches, spoons, scourers, toilet paper, etc. and consolidation of items such as condensed milk with single supply (large tube) rather than several smaller units, would further aid in achieving the set goals.

Initially, DSTO set a target volume commensurate with the weight reduction target set for the LWED CR, when compared with CR1M. This target reduction (~46%) was then considered to be optimised by the decision to assemble and supply as a single entity, rather than as three 24 h packs, a consideration likely to reduce overall dead volume in the assembled pack. DSTO subsequently set a target of 1500 cm³ (a 60% reduction in size when compared with the then current CR1M).

Having considered all information available on existing pack configurations and nutrition recommendations, and having consideration of the operational scenario defined by user representatives, DSTO set the following targets for the design of a LWED CR concept (on a per day basis):

- total weight of ≤ 0.8 kg per day
- total volume of ≤ 1500 cm³ per day
- total energy ~9000 kJ/day

- minimum CHO content 300 g/day
- minimum protein content 50 g/day
- no water required to reconstitute food items
- little/no preparation required (except for reconstituting beverages)
- high organoleptic acceptability
- maximise inclusion of EOTM single serve food items.

3.1.3 Consumer focus groups and product preference

Focus groups were used to identify current CR components and COTS products suitable to meet consumer needs, namely product acceptability and service suitability.

Initially, focus group sessions centred on popular jack rations such as retorted fish and salami-type items as well as noodles, other pasta, confectionery and energy bars (Forbes-Ewan, 2001; Booth et al, 2001). These initial discussions identified other food concepts (both current CR components and COTS items) that were evaluated during subsequent sessions. Formulated beverage powders and gels, similar to those in US military rations, were also presented to focus groups for consideration.

Appendix A contains a list of all products evaluated. The following sub-sections provide detailed evaluations of acceptability and service suitability of product concept/groupings that were considered for this prototype pack.

3.1.3.1 *Energy bars – high in protein and/or CHO*

Focus group discussions identified the need for inclusion of both natural fruit and dessert type bars, to deliver breakfast and dessert options. Improved acceptability and consumption would likely be gained by providing bars that visually depicted ingredient diversity (rather than presenting as a heavily processed/extruded bar). Increased consumption would prevail through product variety in the 72 hour pack.

Ingredients of energy bars varied depending on the specific purpose of each formulation. Generally, energy bars contained a high proportion of CHO, whether simple CHO (sugars) for quick energy release, or complex CHO for slow, sustained release. These bars often had added vitamins and minerals. Energy bar formulations were based largely on fruit and/or cereals and often with a chocolate- or yoghurt-coating.

For service suitability in CR, focus groups identified that product texture must remain acceptable when consumed in a range of climatic conditions—bars should not sweat or wilt in the heat, nor become brittle or hard in cold conditions. The diversity of products allowed DSTO to investigate the characteristics that affected consumer acceptability and service suitability, and also the most appropriate packaging materials.

3.1.3.1.1 High-protein (>25%)

COTS high-protein bars from four suppliers were evaluated (Appendix A, Table A1). The most popular products identified were chocolate-flavoured and chocolate-coated bars. However, focus groups reported an unpleasant dryness in the mouth during consumption of the higher-protein (>30%) bars and they tended to leave an unpleasant, lingering aftertaste. Therefore, several of these bars were excluded when considering plausible options. Focus groups rejected bars that were likely to sweat and wilt in warmer environments.

3.1.3.1.2 Higher-CHO (>50%), lower-protein (<25%)

High-CHO bars—mostly COTS products—from 10 suppliers were evaluated (Appendix A, Table A1). The two most popular bars identified were an extruded strawberry bar and an apple/strawberry slice. Texture ranged from soft and chewy through to hard and crunchy.

3.1.3.2 Confectionery

The scope of confectionery evaluated was broad (Appendix A, Table A2). Focus groups identified soft panned and hard panned confectionery as well as liquorice to be the most popular. However, there was a preference for confectionery that did not adhere to teeth when consumed. Small compact serves of confectionery were requested. Hard caramels would also be moderately well received in CR when compared with other confectionery.

3.1.3.3 Freeze-dried and dehydrated fruits

A wide variety of dried fruits were evaluated (Appendix A, Table A3). To assess individual flavours and textures, each fruit product was evaluated alone (rather than as a mix). Focus groups identified sultanas, banana chips and FD grapes as the most popular fruits. There was a strong preference for mixes rather than individual fruit serves. Inclusion of raisins and dried tropical fruits such as mango was a common request, as was resealable packaging to allow 'grazing'.

Product texture varied due to different levels of moisture; soldiers' preferences were generally for a moister, chewier product. However, drier fruit products typically have a longer SL. FD apple, while not having a high acceptability, was the preferred apple product of those presented. The diced apricots presented to focus groups were much drier than those commonly available; greater acceptability would be anticipated for a moister product.

3.1.3.4 Nuts

Several varieties of flavoured peanuts from two COTS brands were evaluated (Appendix A, Table A4). Even when troops were presented with a variety of novel flavours, the most popular flavours were salted/fried, roasted/salted and honey roasted. Products from each manufacturer were equally acceptable. The preferred peanut product was one reported to have a fatty acid profile that prolongs SL.

3.1.3.5 *Dried and processed meats*

Dried meat products are high in protein and typically rich in iron. Processed meat products such as twiggy sticks, jerky and deli style salami have traditionally been used as jack rations by ADF personnel (Forbes-Ewan, 2001; Carins, 2002). Inclusion of this type of meat-based product in CR was likely to be popular and, more importantly, to make a valuable contribution to the nutrient intake of ADF members.

Several products from three COTS brands were evaluated (Appendix A, Table A5). Hans products have historically been used as jack rations, however they were found to be less acceptable than other products during focus group discussions. A higher fat content and oily mouthfeel were cited as the main reasons for these lower ratings. The most popular products identified were steak bars and beef jerky. There was a preference for teriyaki flavour over peppered flavours among the available steak bars. A natural, unflavoured jerky was preferred over stronger flavoured alternatives.

3.1.3.6 *Sport/energy gels*

COTS gels from nine suppliers were evaluated (Appendix A, Table A6). Many products were considered acceptable, with apple cinnamon, vanilla, citrus and chocolate being the most popular.

Focus group discussions revealed that texture varied between brands, ranging from 'smooth and runny' through to 'thick and pasty' or 'sticky'. Products varied considerably with regard to viscosity, smoothness and flavour intensity. Commercial packaging of gels varied considerably. Most products were in pouches with spout formation. Other forms of packaging included rectangular flat sachets and re-sealable pouches with spouts/screw lids.

Thick, smooth products with no grittiness were preferred to thinner, grittier alternatives. There was a particular dislike for those products that had a medicinal flavour, little flavour or were intense in flavour. Concerns were raised over packaging integrity when used in an operational environment. A common request was for gels in a tube or in a flexible package that was resealable, because consumers did not believe the product would be consumed in its entirety immediately after opening. As the product was somewhat novel to this consumer group, consumer education may be warranted if/when it is included in CR.

At the time of this report, the US Military are investigating the feasibility and formulation of an energy gel with a low glycaemic index (GI) and incorporating a newly developed high-energy-yield resistant starch.¹⁶ A serving size of 60 g should provide 26–28 g CHO, 5–6 g fat and total energy content of 630 kJ. No commercially available gel has been identified that meets all these criteria; the closest would be the chocolate-flavoured gel made available by supplier D in Appendix A, Table A6. This COTS product matches the fat and complex CHO (maltodextrin) profile of the US military equivalent.

¹⁶ <http://nsrdec.natick.army.mil/media/fact/food/perc.pdf>

3.1.3.7 *Processed fish products*

Several products from three COTS brands were evaluated by focus groups (Appendix A, Table A7). The most popular were those with condiment flavourings such as sweet thai chilli and lemon pepper. However, consumers were in favour of including 'plainish' flavours of fish that could be flavoured to each individual's liking with separate condiments. Again, flavour variety was requested. No differences in texture were found between products from the different suppliers. A preference for tuna over salmon was evident from discussions.

3.1.3.8 *Protein-based drink powders*

Thirteen protein-based drink powders, with and without milk solids, were presented to focus groups (Annex A, Table A8). Those without milk solids were found to be 'watery'. Many of those with milk solids were too sweet. The majority of powders did not readily resuspend in water, and those that did required extensive mixing—all undesirable properties in a field environment.

Only one formulation, a strawberry cream variant, was found to be acceptable during focus groups. Unfortunately, this product's serve size was not suitable, and it was not considered cost effective to repackage it for inclusion in a prototype menu.

3.1.3.9 *Bread*

A bread product in CR would serve as an integral adjunct to retort meals and also as an alternative (softer) option to biscuits for consumption of spreads. Focus groups, while they did not quantitatively assess this product concept, did favour the inclusion of tortilla bread in this ration concept.

3.1.4 Component choice and delivery

A balanced consideration was given to the food (and its nutrients), the consumer (expectations, traits and attitudes) and the mission-specific operational constraints (nutrition for performance, load carriage and convenience) when selecting food items for inclusion in the 72 hour pack. Based on focus group discussions, a listing of highly acceptable and likely consumed items was developed in the form of a database that included details of nutrient content for all items likely to be considered in this concept design. It also included all components of the current CR. This database was used as a decision-making tool in devising the composition of each of the three menus to ensure that the nutrient requirement targets were met.

Energy densification was anticipated to facilitate greater nutrient intake, given the soldier was more likely to carry adequate provisions if total weight and volume was kept low. Selection of components was heavily influenced by the requirement for EOTM consumption. Menus were designed to provide seven snacks/meals over the course of the day (refer Appendix D and E), five of which were considered necessary to be EOTM.

With the exception of the evening meal (Meal 6) and beverages, no components required preparation; all could be consumed direct from their packaging. Meal 1 (breakfast)

included a sports drink that could be prepared at breakfast time, but was anticipated to be consumed over the course of the day.

A combination of three high-CHO bars and one high-protein bar was chosen for the 72 hour menu. For the CHO bars, one slice and two extruded bars were chosen to increase variety. CHO bars were all fruit-flavoured. The chosen bars were fortified with a suite of amino acids, probiotics, vitamins and minerals. No bar was chocolate- or yoghurt-coated, even though focus groups preferred these.¹⁷ This exclusion removed many of the otherwise suitable foods from the list of potential items. The third bar, from supplier code AL (Table A1 of Appendix A), was not evaluated by focus groups but was thought to match the desired texture and flavour profile for such bars. Its nutritional benefits (vitamin and mineral fortification) outweighed those of other assessed COTS equivalents.

As a high-protein bar, an extruded chocolate-flavoured bar was selected that was 27% protein, with essential amino acids to aid in muscle recovery. Focus groups indicated that bars with protein content higher than this were not acceptable. Higher protein content required more moisture to masticate and personnel felt these bars left the mouth/palate too dry.

A substantial sit-down meal was included in the menu design, because social interaction has been reported to increase the likelihood of consumption (Meiselman and MacFie, 1996). Social interaction might also be expected to facilitate comradeship and enhance morale within groups. Retort meals, while not nutrient dense, were included for these reasons.

Meal choice was influenced by the requirement for palatability when consumed cold. There was also a requirement to provide a meal that could be prepared with minimal effort. The inclusion of a freeze-dried meal, rather than a retort meal, was considered but was believed to be less appropriate because of the increased requirement for water carriage, low palatability without preparation, and increased effort for preparation.

Focus group consensus identified two of the more viscous retort meals (barbeque (BBQ) chicken and chilli con carne) as the most acceptable retort meals from the suite available in CR. Retort meals were selected for days 1 and 3, with a tuna product and dry, savoury biscuit to be included for variety. Product compatibility was considered when including the savoury biscuit with the pouched tuna and tortilla bread with retort meals. Compatibility also addressed delivery mechanisms for consumption of the wet components, for example, the flour tortilla can be used instead of knife and fork for consuming the retort meal.

Tuna products have traditionally been used as jack rations, and recently tuna pouches were introduced into the CR1M. Tuna and salmon are excellent sources of protein and

¹⁷ Chocolate- and yoghurt-coated products were unlikely to meet ADF SL requirements. These products were excluded from selection in a prototype pack.

good sources of long-chain omega-3 fatty acids (found in fatty fish), which may have several beneficial effects on military health and fitness (Lewis et al, 2011; Lewis & Bailes, 2011; Deuster et al, 2013). Fish is also a good source of vitamins, iodine, fluorine, selenium, iron, zinc, magnesium and other minerals. There being no standout commercial product, the decision was made to use the current CR tuna pouch product, tuna with dried tomato and basil, in the LWED CR prototype menu. A tomato ketchup condiment was also included for day 2 as consumers were in favour of the option to flavour main meals if so desired.

Peanuts are high in protein (~25–30%) so have high satiety. They are energy-dense, and having a low GI (~13), they are a good source of sustained energy release. Peanuts are also high in arginine (good for wound healing and general immunity), vitamin E and dietary fibre and are also a good source of B group vitamins and minerals. Soldier preference was for oil-fried/salted peanuts, so these were included in the prototype menu. Dried fruits – comprising sultanas, apricots and banana chips – were also provided. Rationalisation of snack items led to nuts & sultanas and nuts & apricots mixes being included in the 72 hour design as blends.¹⁸

Soft and hard panned confectionery were both chosen on the basis that they were well liked, easy to consume and rich in vitamin C. The soft panned confectionery was a COTS product, compact and with brand familiarity in its commercial packaging. The hard panned confectionery also held brand familiarity, although this was not immediately evident to the consumer, because military-off-the-shelf (MOTS) packaging was used over the commercial packaging. This was necessary to achieve a smaller desired serve size. Once again, three flavours were provided. Ration chocolate was also included due to its high energy density, ability to cope with high temperatures and fortification with vitamins A, B1 and C. The fat and protein contributed by ration chocolate improved the overall macronutrient content, in addition to vitamin content. It also has a reasonable acceptability rating with troops.

As discussed in section 3.1.3.5, a teriyaki-flavoured steak bar and a natural flavoured beef jerky were included, adding to variety over the 72 hour period. Both meat products made a substantial contribution to the overall protein content of the CR. Both had brand familiarity and were nutrient-dense.

Gels were typically based on CHO, and were highly concentrated in contrast to sports drinks. Gels are compact, easily consumed and quickly digested. The composition of commercially available gels varied with regard to the proportions of simple and complex CHOs, along with fortification of vitamins, salts, amino acids and caffeine (some or all of which may be present). Complex CHO such as maltodextrin provide sustained, slow-release energy, while simple sugars such as glucose and sucrose provide rapid-release energy. Given the variety available, three quite different products (in formulation and flavour profile) were chosen for inclusion in the prototype. These were:

¹⁸ In hindsight, a salted nut was not an ideal choice to blend with fruits. Consumers did not expect, nor desire, salted fruits in the CR design.

- formulation 1 – flavour: apple cinnamon; CHO breakdown: complex 90%/sugars 10%, supplemented with sodium and potassium
- formulation 2 – flavour: vanilla; CHO breakdown: complex 60%/sugars 40%, supplemented with sodium potassium and caffeine
- formulation 3 – flavour: chocolate; CHO breakdown: complex 75%/sugars 25%, supplemented with sodium and potassium.

Two varieties of a chocolate drink were included (Annex A, Table 10). These products, while not having been evaluated by consumers, held brand familiarity and were expected to be well received. None of the protein drinks evaluated by focus groups were judged suitable. The choice to use an untested product, while not evaluated by focus groups, did reflect consumer preference for flavour profile and ease of preparation when other protein-based drink powders were discussed. Both provided health benefits, being vitamin-fortified and low in GI. The 35 g serve offered further health benefits, with inclusion of oat bran and other high-fibre ingredients.

COTS electrolyte sports drink were not evaluated by focus groups. The decision was made to include three flavours of current CR beverage. The CR product was relatively new, fortified with vitamin C and was reported anecdotally to be well received by ADF consumers. As it had only recently been included in CR menus, product boredom was not expected to limit acceptability.

The pack provided food for 72 hours. However, rather than being issued as three 24 hour packs, it was issued as one 72 hour pack, with minimal duplication of common items. As examples, there was one tube of sweetened condensed milk, one plastic spoon, two boxes of matches and so on, rather than three of each. A stripped version of the brew kit was also provided. This was as much for ‘comfort’ as for nutritional benefit. As consumer preference typically is bi-modal between tea and coffee, DSTO assumed that those who had preference for one over the other would exchange items with other troops.

The use of rigid packaging such as cans and aluminium tubes was minimal, with only the sweetened condensed milk being packaged in this form. To ensure convenience, all products and packaging were robust. Packaging weight and quantity of packaging were kept to a minimum.

Twenty of the 28 products included in the menu design (not including common and sundry items) were COTS and several of these were included in commercial packaging. Brand familiarity is believed to increase acceptability and thereby lead to increased consumption (Meiselman and MacFie, 1996). Commercially sourced products were only packaged in MOTS packaging when serve size and/or appropriate fruit and/or nut blends could not be sourced commercially.

Appendix D provides further detail of considerations and influences in product selection for inclusion in the concept pack. The menu sheet is shown at Appendix E.

3.1.5 Hitting the mark; achieving the goals set

Appendix F contains a full breakdown of the nutritional profile for each of the three menus of the 72 hour prototype pack.¹⁹ The LWED CR was designed for use by highly mobile units engaged in activities lasting up to 72 hours. It provided ~9000 kJ, which was approximately 2/3 of the 15 000 kJ required daily by an active soldier (Forbes-Ewan, 2009). Overall, 14% of energy was derived from protein, 20% from fat, and 66% from CHO. It is important to note that complete food composition data were not available for all of the items used in this ration design, especially micronutrient composition data.

The weight and bulk were less than half those of the current CR1M (Table 1). The final design had no requirement for water to reconstitute food items, and no preparation was required to consume items other than beverages. The main meals could be consumed cold. All components were considered to have high organoleptic acceptability. After 72 hours, other rationing (either fresh or 24 hour CR) would be required.

As Table 1 illustrates, the prototype pack achieved (if not exceeded) weight and nutrient requirements. However, the requirement for volume was not achieved. Future improvements such as reducing the headspace volume of several packaged products (including confectionery, commercial bars and protein drink powder) will reduce the dead volume contained within packages. Increasing the density of several products (such as aerated bars) may also aid in achieving the specified volume. Extruded bars tend to be denser than their baked equivalents. However, this should be exercised with caution as it will likely affect the texture and appearance of the bars. Retort meals contain significant moisture. If this can be reduced in a balanced manner that addresses weight, bulk and palatability, it will also result in less weight and volume.

3.2 Field testing of the concept ration

Unfortunately, the trial program did not proceed according to plan. Of the 150 ADF personnel who volunteered to take part, 80 were deployed overseas just hours before the trial was due to commence. Subsequently, 70 male soldiers were engaged in an airborne insertion and subsequent operational activities for 72 hours. In addition, three participants left the study prior to completion due to injury, illness, or for personal reasons.

¹⁹ Nutritional content is based solely on the nutrition information panel (NIP) data contained on packaging for both CR and COTS items. As such, little is known of the micronutrient content of the menus devised.

Table 1 Achievement of design, configuration and nutrient criteria set for the LWED CR concept

	Recommended Nutritional Criterion for CR		Current <i>Combat Ration One Man (CR1M)</i>		Program objective <i>Light Weight, Energy Dense CR (LWED CR)</i>		Current	
Volume (cc)*	-		3570		~1500		~1700	
Weight (kg)	-		1.75		0.8		0.8	
Energy (kJ)	15 000		15 900		~9000		8825	
	g	% EC#	g	% EC	g	% EC	g	% EC
Carbohydrate (g)	525–553	56–59	624	65	> 300	-	340	66%
Protein (g)	106–132	12–15	97	11	> 50	-	70	14%
Fat (g)	118	29	116	25	-	-	51	20%
* including accessories/sundries				Legend: Meets goal (within 5%)				green
# EC= Energy contribution				Positive departure from goal (> 5%)				blue
				Negative departure from goal (> 5%)				orange

3.2.1 Demographics of trial group

On completion of the 72 hour trial period, waste (all packaging and non-consumed food items) was collected and recorded from 35 personnel. Given the operational intensity and complexity of the exercise underway, DSTO (with military liaison) had limited visibility of participants within the exercise area. Their locations were widespread for waste collection and questionnaire administration. Questionnaires were collected from 50 personnel. Data from the 15 participants who completed the survey but did not submit their waste were not included in the final data set. Demographics for the participants who completed the study are shown below in Table 2.

3.2.2 Mission, locality and environmental stresses

The climatic conditions and geographical location were not known nor defined by the user when the ration was designed. The ADF deploys to many and varied environments, including hot/dry, hot/wet, cold/dry, cold/wet, and cold/high altitude. While it is expected that the mission tempo, environment and locality will affect the nutrient requirements, food preferences, acceptability and eating behaviour, these variables were not determined during this study. During the study the weather was cold and humid, with rain most days. Soldiers undertook various activities, including an initial parachute insertion, followed by infantry tactics.

Table 2 Demographics of the trial participants

Demographic	Group	Number	Age	Years of service
			Mean (Range)	Mean (Range)
Age	All	35	26.1 (20–44)	5.4 (0.25–23)
	25 or younger	21		
	26 or older	14		
Years of service	All	35		
	4 or less	15		
	5 or more	20		

Details of activities, intensity and duration were not made available to DSTO. The weather conditions experienced were considered atypical for the exercise location. Given the weather conditions, depressed acceptability and consumption of the ration concept during the exercise was expected. A repeat study, with consumption under more favourable weather conditions, may result in greater food intake.

3.2.3 Product palatability, consumption and provisioning

There was a general liking for most food, beverage and ancillary items in the prototype pack. With the exception of the chocolate-flavoured gel and ration chocolate, all items had over 50% support in the *like* direction. No item scored highly in the *dislike* direction. Attitudes towards the quantity of food provided varied. For most items, respondents were split between *enough* and *not enough*. In general, consumption rates were high. Consumption of gels and beverages (sports drink, coffee and tea) was variable, with partial consumption most frequent.

The substantial inclusion of EOTM elements was well received.

In some instances the return rate of packaging was low. This introduced an element of uncertainty into the data set for consumption patterns. It may be that, for items where acceptability was high, ADF personnel retained non-consumed product for later consumption. The converse may also be true, i.e. products that did not rate well may have been discarded, so consumption rates may have been over-estimated.

For the purposes of further product evaluation, ration items were categorised into food groups. Outliers were identified in many of the data sets, however these were retained for statistical analysis. Details of outliers are reported in Appendix G. The Shapiro-Wilk test for normality ($p > 0.05$) found all data sets to be 'not normally distributed'. As such both t-tests and non-parametric tests have been applied to each data set. Full results can be found in Appendix G.

3.2.3.1 Food bars

Figure 2 provides a graphical display of the palatability, adequacy of serve size and consumption patterns for each of the food bars included in the 72 hour pack. The average acceptability rating for all food bars was greater than the target of 3. With the exception of

apple/strawberry slice, ratings were significantly greater ($p < 0.02$) than the target value. Average consumption for all bars was $\geq 95\%$. Portion size of the apple/strawberry slice was considered adequate, however portion size of other bars was rated significantly ($p < 0.025$) inadequate.

Based on comments, the apple/strawberry slice was the least preferred bar, the major cited reasons being poor texture, taste and appearance. However, despite these criticisms consumption was not significantly different from those of other more favoured bars. The apple bar was reported to have a bland flavour, with other fruit flavours being preferred.

Overall, the chocolate bar and strawberry bar performed best. They were both nutrient-dense and minimal in volume. Both are worthy of consideration for inclusion in future CR configurations.

3.2.3.2 Confectionery

The soft panned confectionery (SPC) was the most popular confectionery, with hard panned fruit-flavoured confectionery (HPFC) also rating well. Figure 3 provides a graphical display of the palatability, adequacy of serve size and consumption patterns for each of the confectionery products. The average acceptability rating for the SPC was significantly ($p < 0.001$) greater than the target of 3. Portion size was considered significantly inadequate ($p < 0.003$) and consumption was significantly greater ($p < 0.001$) than the target value.

The acceptability of ration chocolate, while not statistically significantly different from the desired result, did fall marginally below the acceptance criteria.²⁰ Ration chocolate has historically been considered as one of the more acceptable products in CR, yet this study found respondents were divided in 'liking' and 'disliking' of it. Reasons given for the low acceptability and consumption (85%) were predominantly taste and 'palate fatigue' (i.e. tiring of the product). More than 20% of respondents considered there was *too much* chocolate (Figure 3b). Similarly, it was not wholly consumed by more than 20% of respondents. It is somewhat concerning that consumption of ration chocolate was very low, despite participants reporting that they generally felt hungry after the 72 hour trial.

Bui, McLaughlin and Coad (2014) recently reported ration chocolate to be one of the few ration components that provide essential micronutrients (vitamins A, B1 and C). It is imperative that this product be retained in CR and product improvements need to be made to ensure its palatability and ultimately consumption rates are adequate.

Both SPC and HPFC, with an increased serve size, deserve to be considered for inclusion in future CR configurations.

3.2.3.3 Dried fruits and nuts

Figure 4 provides a graphical display of the palatability, adequacy of serve size and consumption patterns for each of the fruit and/or nut combinations. The average

²⁰ Here, the mean result has fallen below the AQL and as such has failed (in isolation) to meet the requirement. With further consideration of the calculated 95% CI, this failure is not statistically significantly different from the AQL until a later time in the study. Note: Several instances of this finding are later reported also.

acceptability rating for all fruit and nut products was significantly ($p<0.005$) greater than the target of 3. Portion size was appropriate for banana chips, however significantly ($p<0.03$) insufficient for fruit/nut mixes and sultanas. Consumption rates for each were around the 90% target value, with no product returning an average consumption rate significantly different from the target. Sultanas and banana chips were least preferred and the major reasons given for this were taste and personal preference for other dried fruit products. However, their consumption rates were apparently not affected by these relatively low acceptability ratings. Few respondents considered there to be *too much*, and there was a preference for increasing the serve size of components containing nuts.

Dried fruit and nut mixes are nutrient-dense, healthy and highly favoured by ADF personnel, so are worthy of consideration for inclusion in future CR configurations.

3.2.3.4 *Dried/processed meat products*

Figure 5 provides a graphical display of the palatability, adequacy of serve size and consumption patterns for the two meat products included in the 72 hour pack. Both the steak bar and jerky products rated significantly higher than the target acceptance value ($p<0.001$). Portion size was considered significantly inadequate ($p<0.001$) and consumption was significantly greater ($p<0.001$) than the target.

Steak bar and jerky products, with increased serve size, are worthy of consideration for inclusion in future CR configurations.

3.2.3.5 *Sports gels*

Figure 6 provides a graphical display of the palatability, adequacy of serve size and consumption patterns for the sports gels. Although the serve size was considered adequate, no sports gel scored highly for acceptability, with ratings all around the target value and none significantly different from this target. The chocolate-flavoured gel was least preferred, achieving an average acceptability rating below the target of 3. Taste was the major reason given for why products were not liked. Consumption rates for both the chocolate- and vanilla-flavoured products were significantly ($p<0.04$) below the target of 90%. A resealable package may lead to increased consumption as the intense flavours are likely to limit the amount consumed at any one occasion.

Commercially available sports gels deliver a dense, niche profile of CHO, vitamins and minerals (refer Table 2), one that is somewhat lacking but necessary in CR. Further work is required to understand consumer attitudes and preferences (e.g. for flavour, texture and packaging) before this product concept is considered for inclusion in CR.

3.2.3.6 *Main (evening) meals*

Figure 7 indicates that there was a general liking for all main meals and adjunct items. The acceptability of all items was significantly greater ($p<0.05$) than the target of 3. BBQ chicken was the least preferred item in this product group due mostly to taste, individual taste preferences and product compatibility. The watery nature of the BBQ chicken 'wet through' the flour tortilla and reduced the overall palatability of the meal. Several respondents also expressed palate fatigue as a reason for their dislike of BBQ chicken.

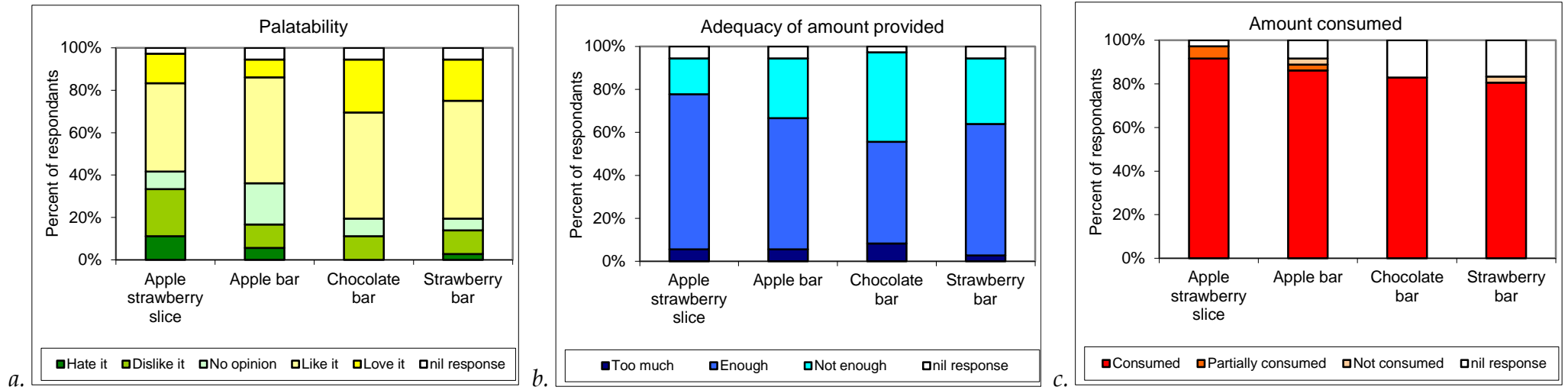


Figure 2 Acceptability and consumption of food bars: a) Palatability, b) Portion provided and c) Amount consumed

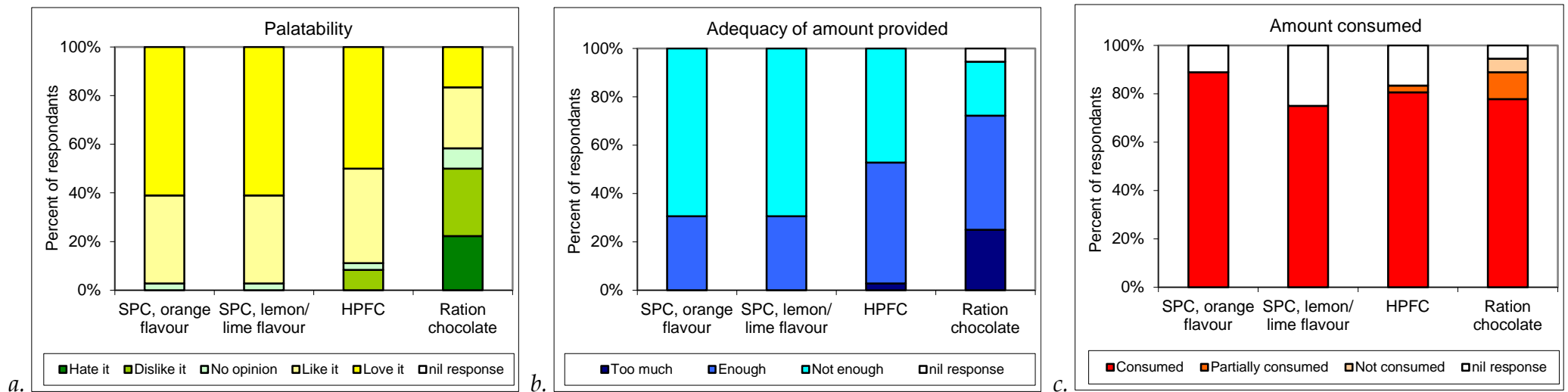
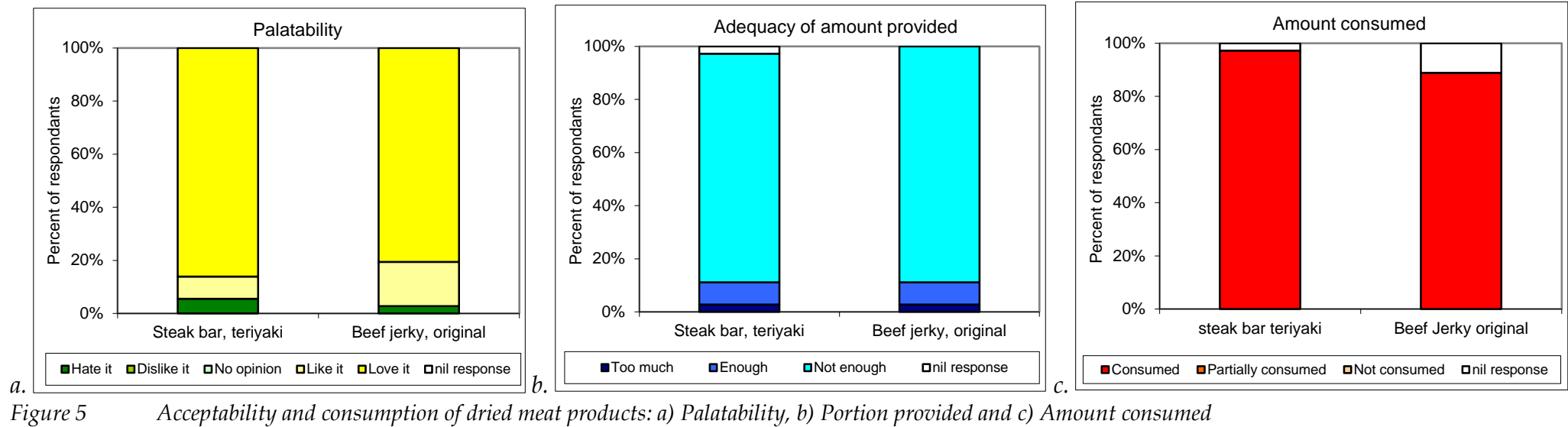
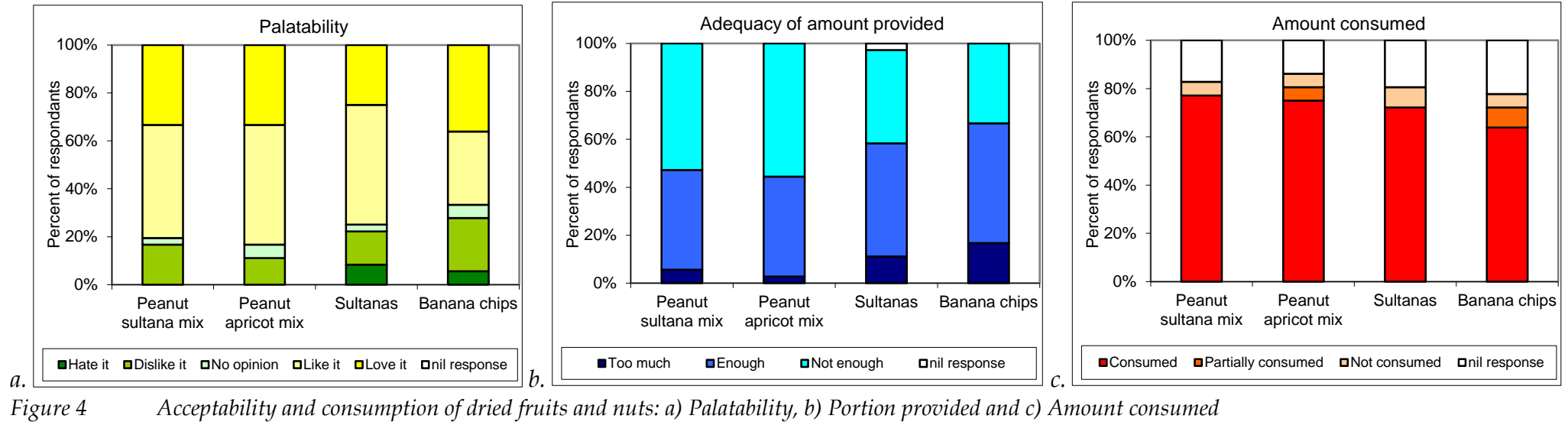


Figure 3 Acceptability and consumption of confectionery: a) Palatability, b) Portion provided and c) Amount consumed



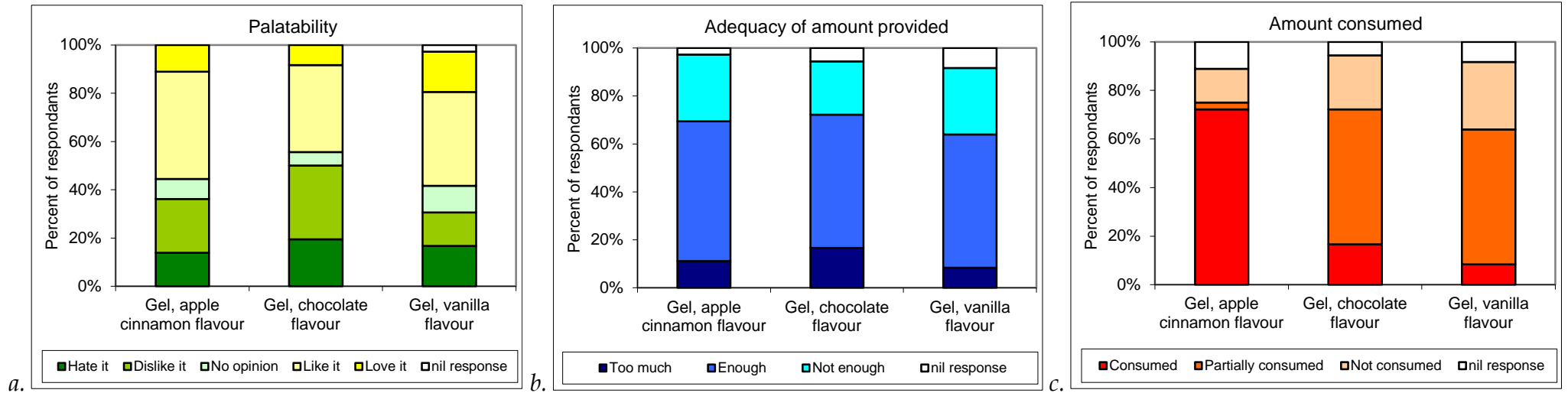


Figure 6 Acceptability and consumption of sports gels: a) Palatability, b) Portion provided and c) Amount consumed

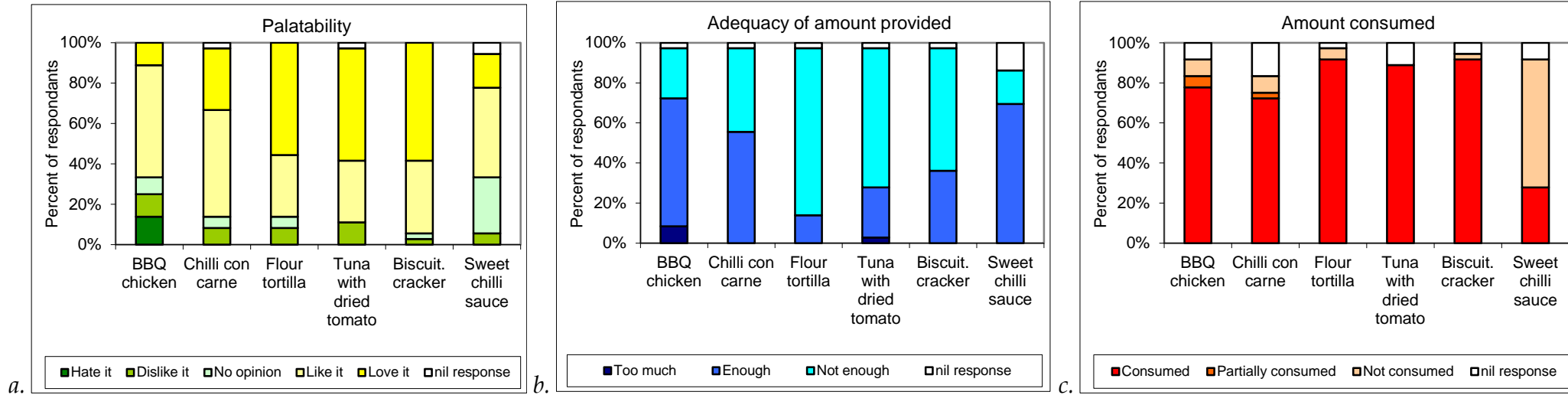


Figure 7 Acceptability and consumption of evening meal items: a) Palatability, b) Portion provided and c) Amount consumed

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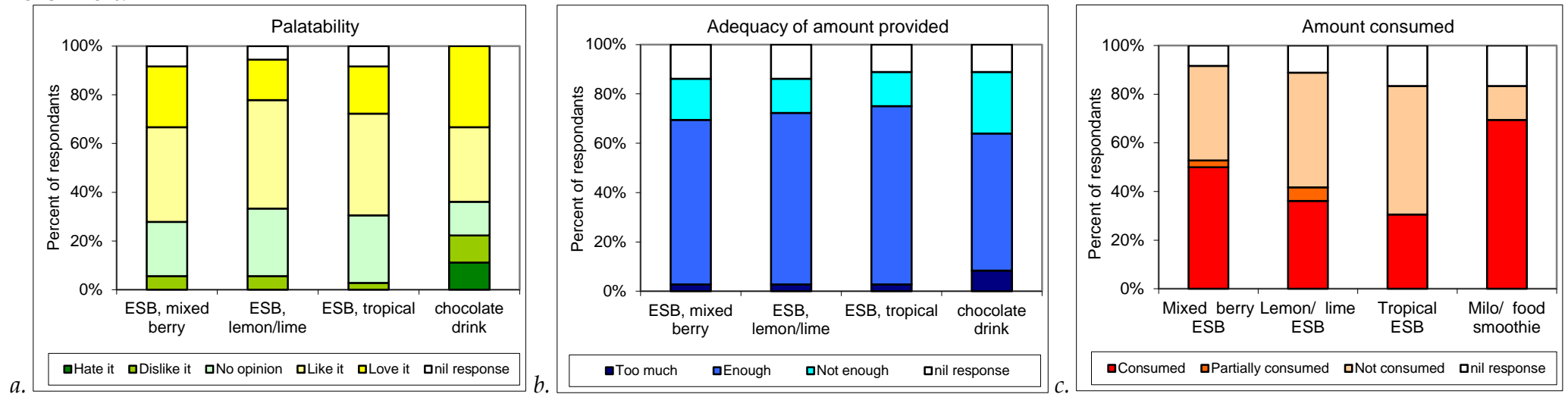


Figure 8 Acceptability and consumption of beverages: a) Palatability, b) Portion provided and c) Amount consumed

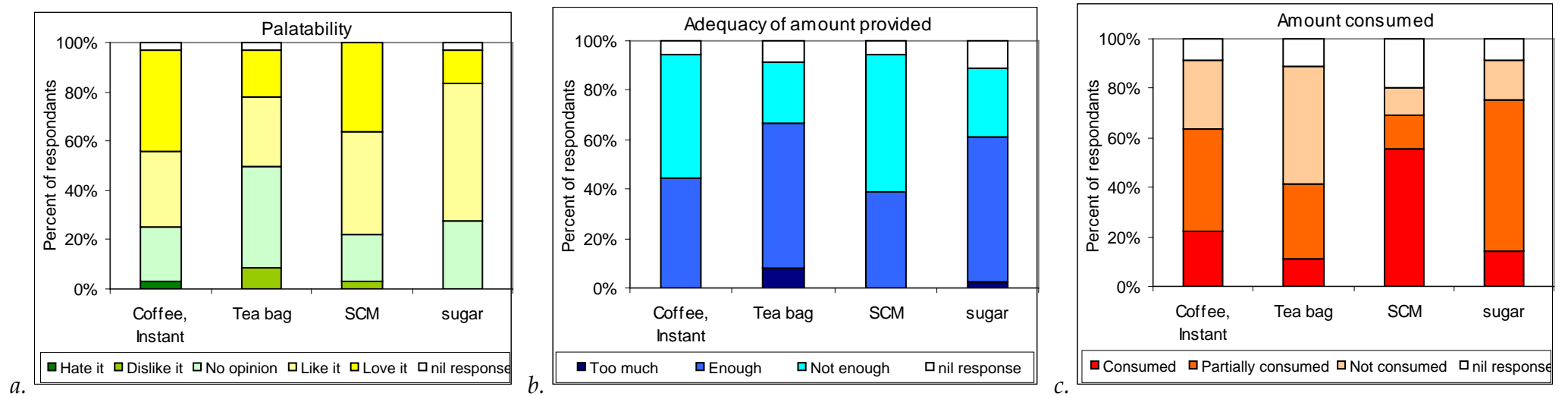


Figure 9 Acceptability and consumption of 'brew kit' items: a) Palatability, b) Portion provided and c) Amount consumed

Consumption rates for all items except the sweet chilli sauce were high. Flour tortilla²¹, tuna and cracker biscuit were all consumed at rates significantly above ($p<0.05$) the 90% target. Respondents frequently commented on the fact that the flour tortilla was 'out-of-date', stale and readily fell apart. Even with all this negative feedback, the product was still highly consumed. Tuna was recently added to CR as a light meal component.

The novelty of a popular addition is likely to have been a factor in its preferred liking over the retort meals.

While the average consumption rate for retort meals was below the 90% target, the results were not significantly different from this value. However, improvement in the overall quality of the BBQ chicken toward a more appealing, appetising and palatable product would likely improve acceptability and consumption rate. The introduction of novel main meals is also likely to reduce boredom.

The sauce adjunct was not well consumed (30%) and significantly ($p=0.001$) below the target value. Removal of this adjunct is not likely to affect the palatability and/or consumption of main meals, especially if flavoured varieties of tuna are included in CR. Portion sizes for the flour tortilla, tuna and cracker biscuit were regarded as insufficient, while the main meals (retort pouches) provided adequate food.

It was apparent that ADF personnel reached a state of greater palate fatigue with main meal components than with the snack items. Main meals provide a more substantial volume of food in one instance, when compared with EOTM items, and this may have heightened the rate of boredom.

3.2.3.7 Beverages (cold)

Figure 8 provides a graphical display of the palatability, adequacy of serve size and consumption patterns for the beverages included in the 72 hour pack. The average acceptability rating for all beverages was significantly ($p<0.01$) greater than the target of 3. Average portion size was considered adequate, however partial consumption of the electrolyte sports beverage (ESB) powders was common. Consumption rate for ESBs was in the range 30–60%, significantly lower than the target of 90%. The current CR single serve (70 g) makes one litre of drink and it is likely that personnel did not prepare one litre of sports drink for consumption at any given time. Consideration should be given to reducing the serve size of sports drink powders. A resealable package and/or provisioning of several smaller serve size options may encourage greater consumption of sports drink. ADF personnel frequently reported that CR contained too much sugar, and a reduction in the provision of sugar-based drink powders is advised.

No item scored significantly higher than the target set for consumption. The chocolate drinks (mix and smoothie) had typical consumption rates in the range 75–90%. The plain formulation (without oat bran) was favoured. The solid nature (texture) of oat bran in the smoothie formulation was less preferred by consumers.

The COTS chocolate drinks included in this concept ration were fortified with a diverse range of vitamins and minerals. The inclusion of a chocolate drink product, fortified with

²¹ When consumed with chilli con carne retort meal.

vitamins and minerals, is worthy of further consideration. The two products included in this study are candidates.

3.2.3.8 *Brew kit*

Figure 9 provides a graphical display of the palatability, adequacy of serve and consumption patterns for the brew kit included in the 72 hour pack. Personal preference played a major part in consumption of items within the brew kit. Consumers typically had a strong preference for either coffee or tea (or neither), and there were similar strong differences of opinion about whether the beverage should be consumed with or without milk and/or sugar. This was evident by the diverse spread and often low consumption rates of the various elements of the brew kit. However, the average consumption rate for the sweetened condensed milk, while marginally below the target value, was not statistically significantly different from the target.

All components of the brew kit returned average acceptability ratings significantly ($p < 0.001$) above the criteria set. No component was considered to have been provided in excessive quantity.

3.2.4 Service suitability of ancillary items

Figure 10 illustrates respondent consideration of service suitability (Figure 10a) and likeability (Figure 10b) of ancillary items in the LWED CR prototype. The inclusion of two types of matches was considered excessive and respondents frequently reported that the boxed matches were ineffective. The average suitability of waterproof matches was significantly above the target ($p < 0.001$), but not the boxed matches. Matches were commonly considered to be present in excess of requirement, so the removal of boxed matches may be worth consideration.

The spoon was considered to be of better quality than the one previously used in CR, and the scourers were frequently reported to be an unused item. Inclusion of more resealable bags may be warranted, based on the results reported here.

The quantity of toilet paper appeared to be appropriate.

3.2.5 Overall ration pack

On the whole, the design elements of the 72 hour prototype pack were considered *manageable to ideal* (Figure 11). Very few respondents were concerned with the weight, water requirement or waste generated by the concept pack. No respondent was concerned by the total size. Noteworthy was the consensus on both size and waste management issues across all demographic groups. However, younger troops and those who had not subsisted on CR for long periods were more favourable towards both water demand and weight of the pack than more experienced troops and those who had subsisted on CR for long periods.

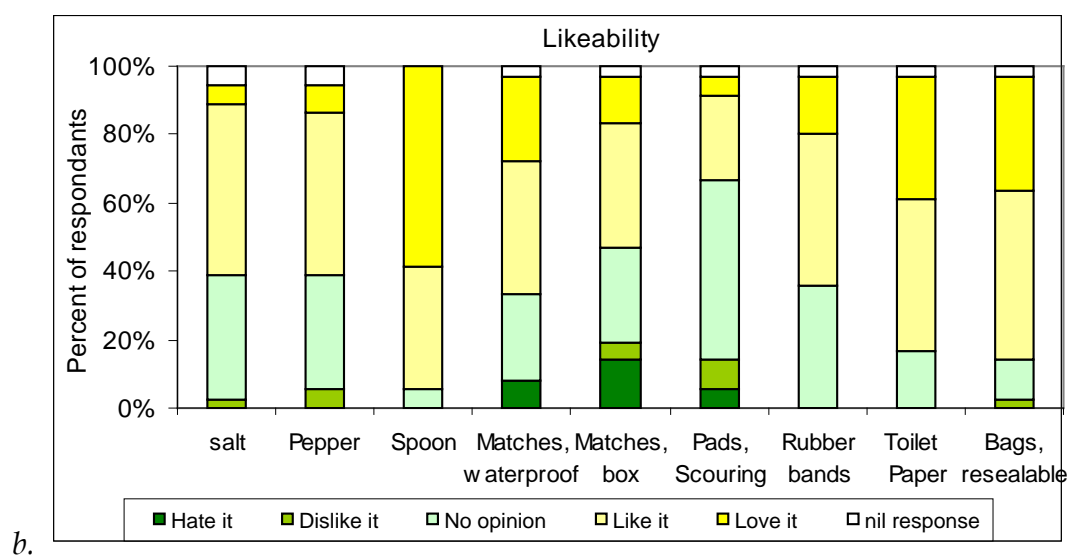
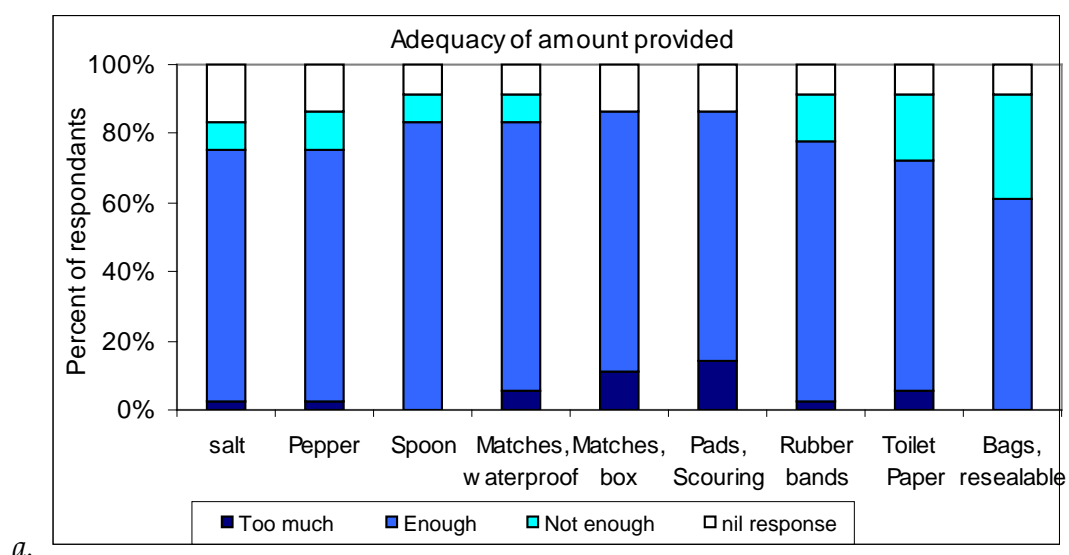


Figure 10 Service suitability of ancillary items: a) Amount provided and b) Likeability

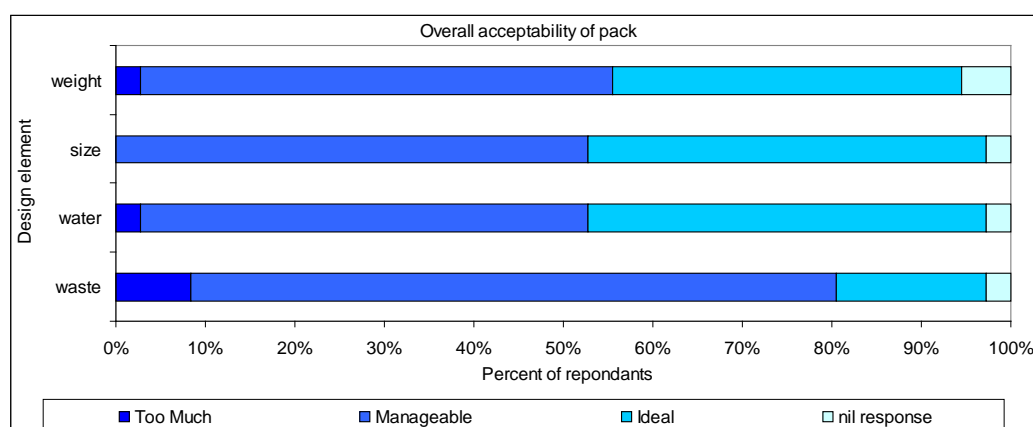


Figure 11 Overall acceptability of the prototype pack design elements

No respondent indicated having taken jack rations. Very few respondents indicated having given away food items. Fruit/nut mix, sports gels, banana chips, beef jerky and ration chocolate were mentioned as traded items. Coffee and HPFC were popular items to receive and consume from others. SPC, ration chocolate, drink powders, tuna, beef jerky, banana chips and food bars were also mentioned as additional items exchanged.

When asked to comment on suitable inclusion of a number of proposed product concepts in this CR design, the study group were largely in favour of dried beef products, tuna, bread, nuts, fruits and savoury biscuits (Table 3). Not surprisingly, these are all savoury food items. Table 3 provides a summary of the comments typically made for each of the product concepts. Brand familiarity/popularity featured heavily in product preferences. There were also many requests to increase the serve size of novel products, including dried meats, tuna and EOTM items.

Table 3 Popularity of suggested product concepts for inclusion in a LWED CR

Product concept	% in favour of inclusion	Comments
Dried beef	97	Products included in this concept pack were popular choices. Greater provisioning was requested.
Tuna	97	Greenseas was a popular brand; preference was for flavoured varieties over plain; greater quantity was requested.
Bread	94	Tortilla or pitta bread preferred.
Salted nuts	91	Peanuts and cashews were most common requests.
Savoury biscuits	91	Arnotts Shapes was a popular brand request.
Dried fruit	83	Include sultanas, apricots, apple, pineapple.
Trail mix	83	Any with inclusion of nuts.
Coffee/tea	80	Nescafe was a popular brand request.
Sweets/confectionery	80	Chocolate was a popular choice.
skittles	74	-
Sports bar	71	Apple and apple/strawberry bars should be replaced with other alternatives.
Sweetened condensed milk	71	-
Breakfast bars	69	Kelloggs breakfast bar was a popular brand choice.
Retort meal	69	Greater variety was frequently requested.
Condiments	66	Garlic and Tabasco sauce were frequently requested.
Sports drink powder	57	-
FD meal	51	Current Patrol Ration One Man meals were considered appropriate.
Fruit	49	Preference for wet (retorted) fruit products was evident.
Sports gels	49	-
Protein shakes	43	-
Ration chocolate	37	Cadbury's was a popular brand request.
Dried milk powder	34	-
Breakfast cereal	31	Consider muesli or porridge.

3.2.5.1 Water carriage, consumption and re-supply

While DSTO was not required to consider overall water requirements in designing this CR, certain hydration issues were considered necessary for optimal composition of the ration and its acceptability and consumption. For example, beverage powders would require rehydration for consumption. It is critical to ensure there is enough water for palatability, digestion of macronutrients (namely carbohydrate and protein) and to compensate for sweat losses. Therefore, a 'water budget' was devised for the concept pack.

Water consumption on-board the flight was no greater than 2 L, and no water was consumed by 54% of respondents consumed no water during this phase. Of those who did consume some water, 42% drank ~1 L. Twenty-eight personnel indicated they received a re-supply of water during the 72 hour period, six did not receive any water, and two did not respond. Of those who were resupplied, one indicated he received 7 litres at the drop zone.²² One respondent indicated having sourced water from rainfall. Quantities of water estimated to have been re-supplied during the 72 hour period and percentages of respondents receiving those quantities were 2–4 L (36%), 5–7 L (21%) and 8–10 L (29%). Three respondents stated that they were re-supplied between 12 and 16 L, while one claimed to have received 24 L.

More important was the total quantity of water consumed over the trial period. Figure 12 illustrates the frequency distribution of total water consumed by individuals. The most common consumption level was 8–10 L, with the majority of troops consuming in the range 5–13 L. There was no evidence to suggest that water consumption on any given day varied substantially from any other.

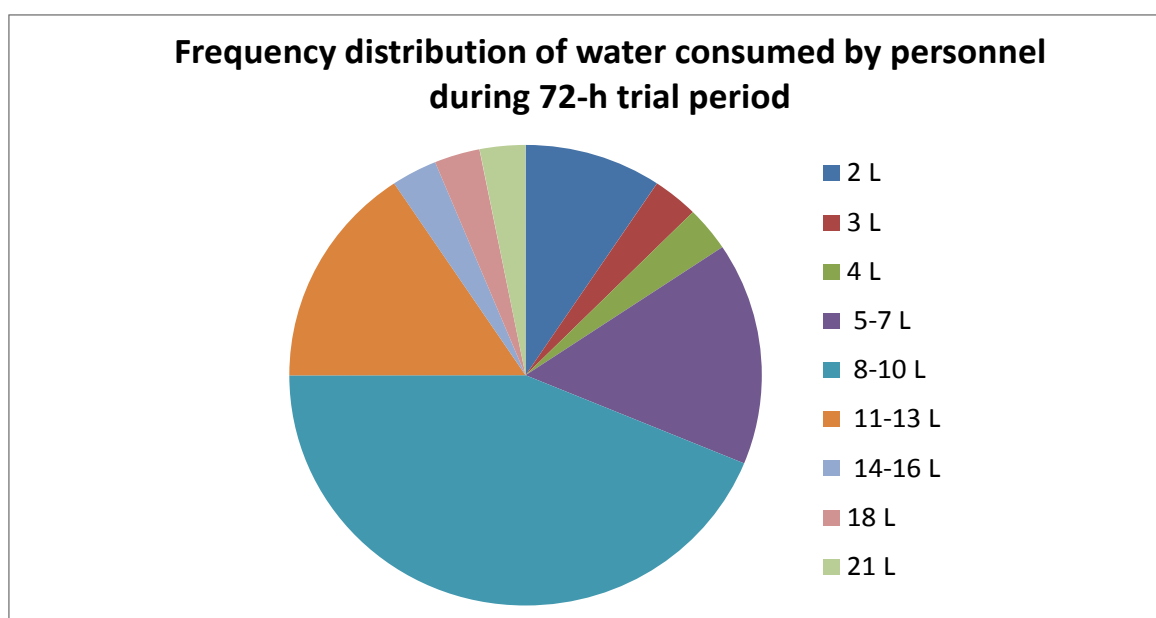


Figure 12 Water consumption during 72 hour trial period²³

²² This respondent did not carry water during the flight. A 159-kg parachute limit applied. Without water his jump weight was 158 kg.

²³ Results are based on the quantities reported by the 32 respondents who indicated either carrying an initial quantity of water and/or seeking re-supply

It was evident from the water carriage and consumption data that some personnel consumed more water than they were resupplied, while others indicated they did not consume all that they sourced. This may indicate that personnel gave away water for consumption by others; therefore an accurate understanding of individual water consumption was not achieved.

3.2.5.2 Preparation and ease of use

While food products were generally consumed as anticipated, there were a few noteworthy exceptions. Table 4 shows that drink powders—intended to be reconstituted prior to consumption—are sometimes being consumed on a dry basis. The effectiveness of the electrolyte capacity of sports drinks comes into question if these products are being consumed dry on a regular basis.

Table 4 Frequency distribution of preparation and consumption patterns of consumers²⁴

Food/beverage item	Method of preparation and consumption		
	Consumed direct from packaging, no preparation	Removed from packaging, consumed without preparation	Removed from packaging, prepared before consuming
Sports drink powders	9	4	19
Sports gels	30	4	3
Brew kit	1	1	31
Milo/food smoothie	22	2	10
Retort meals	22	5	10
Tuna	28	6	3
Dried meat products	32	4	1
Bars and slices	31	4	1
Confectionery	31	4	1
Fruit and/or nut products	30	5	1

Not surprisingly, retort products were consumed with or without preparation.

3.3 Nutrient intake

Nutrient intake was calculated using nutrient composition reported in nutrition information panels (NIP) for each food item and from analysis of each individual's waste (all packaging and non-consumed food items). The following nutrient intake results are based on the assumption that when no package was in an individual's waste bag, the item was partially (50%) consumed. It was also assumed that the one-third of the contents of the brew kit was consumed each day for the three days of the trial.

Table 5 shows the daily mean intakes for energy, fat, protein, CHO and sodium. Indicative values for protein were also calculated with the anticipation that values would be higher, given that a number of NIPs did not report values for dietary fibre. Appendix G, Table G1 provides a detailed breakdown of the daily nutrient provisions.

²⁴ Respondents were able to affirm more than one option for preparation/consumption. There were also instances of no response.

Table 5 *Average nutrient intake and percentage consumption against amount provided*

	Energy (kJ)	Fat (g)	Fat, sat [#] (g)	Protein (g)	CHO (g)	Sugar (g)	fibre (g)	Sodium (mg)
Mean intake	6487	36.3	17.0	56.6	244	144	9.2	1588
Average provision	8825	51.5	22.1	69.8	340	214	11.8	2481
% consumption	78.5	70.5	76.9	81.1	71.8	67.3	78.0	64.0

[#] saturated

At 6487 kJ (78.5% of the energy provided), mean energy intake was disappointingly low. The initial energy target for this ration concept was 9000 kJ, and a 90% consumption rate was expected. The prototype's energy content and consumption were both below the targets. It is not known whether this low level of energy intake had any detrimental effects on cognitive and/or physical performance. It would be appropriate for future research into design and evaluation of a LWED CR to investigate the effect of nutrient deficiency on performance.

The amount of sugar consumed was the lowest of all the foods evaluated. This may be indicative of food preferences toward a savoury profile and away from a sweet profile. Focus group discussions revealed that ADF personnel believed CR to contain too many sweet items. Future improvements to the ration concept should consider reducing the amount of sweet foods included. Total carbohydrate consumption was also low. Replacing some of the sugar content with complex (savory) CHO foods may improve the consumption rates for total CHO. This in turn would improve the overall energy consumption.

In considering the consumption rates of individual ration components, sports drink powders and sports gels were the least consumed items. Both provide energy in the form of sugar. Poor consumption of these items was the main reason for low energy intake during this study.

Protein consumption (81% of the protein available) was close to the target of 90%. The observed consumption of 57 g of protein per day exceeded the initial target of 50 g. Personnel frequently reported feeling hungry at the conclusion of the 72 hour period. While the protein provided may have been adequate to meet nutrient requirements, it was not sufficient to provide adequate satiety.

3.4 Shelf life evaluation

Changes in food characteristics during storage were expected. The rate and extent of deterioration of multi-component foods depends on product formulation, processing, packaging, storage, handling and distribution (Kilcast and Subramaniam, 2000; New Zealand Food Safety Authority, 2005; Man, 2002).

3.4.1 Food bars

The concept ration contained four COTS food bars—none of which met SL requirements. Non-enzymatic browning (NEB) directly influenced aroma, appearance and flavour ratings. Textural changes due to moisture migration were also evident. The commercial packaging material, typically containing a metallised polymer layer for preservation, was ineffective.

3.4.1.1 *Apple/strawberry slice*

The COTS apple/strawberry slice was placed on storage profile 1 (Table C1 and Appendix C) to assess its stability over long storage periods at more enduring temperature conditions. Being a baked, intermediate moisture food, this product was not anticipated to meet SL requirements.

Mean results fell below the AQL (of 5) for all quality attributes after storage for 18 months at 20 and 30 °C. Results at 30 °C were significantly ($p < 0.05$) below the AQL. After eight months at 37 °C and one month at 48 °C results also fell below the AQL. Browning, flavour taints and drying were the major deteriorations noted by panellists.

Cereal products in the form of cakes and slices have not been used in CR unless they have been retorted. Smart ingredient choice and processing technologies (including hurdle technology) show promise in producing a cake/slice product suitable for use in CR. The texture of this product was appealing to consumers, as it was novel when compared with the current suite of CR components. It is likely to be well received if the required SL can be achieved.

3.4.1.2 *Fruit, nut and cereal bar*

The COTS fruit, nut and cereal bar was placed on storage profile 2 (Table C1 and Appendix C) to assess stability following short-term storage at high temperatures.

Significant differences in the quality were found following ASLT. When stored at 37 °C the mean ratings fell below the AQL for appearance, flavour and overall acceptability after two months. Ratings were significantly ($p < 0.02$) below AQL after six months. At 48 °C ratings for appearance, flavour and overall acceptability were all significantly ($p < 0.01$) different from initial quality and fell below the AQL after two, four and four months respectively. Ratings for appearance, flavour and overall acceptability declined significantly ($p < 0.05$) and were below AQL after one month at 55 °C. NEB directly influenced aroma, appearance and flavour ratings. No significant change in texture was observed, suggesting the COTS packaging was suitable for product preservation.

The bar contained fruit, nut and cereal, each of which reduces shelf stability. Combining these ingredients with the bar's relatively high moisture content inevitably resulted in the failure of this product to achieve adequate SL. Product reformulation and/or innovative processing techniques may aid in achieving the required product stability.

3.4.1.3 *Chocolate bar*

The COTS chocolate bar was placed on ASLT profile 2 (Table C1 of Appendix C) to assess stability following short-term storage at high temperatures.²⁵

Significant differences in the quality were found following ASLT. Stored at 30 and 37 °C, the texture was the first attribute to fail. At 37 °C the flavour and overall acceptability failed at two months respectively, although not significantly different from initial quality over six months. After two months, ratings for texture and overall acceptability were significantly ($p<0.01$) lower than the initial values for samples stored at 48 °C. After four months storage, texture, flavour and overall acceptability were significantly ($p<0.007$) below the AQL. Similar effects were observed in samples stored at 55 °C, with the overall acceptability ratings failing after just two weeks. Comments from panellists suggested that the product hardened (dried out) during storage. Flavour loss was followed by the development of burnt notes.

No significant change in appearance was observed during ASLT. NEB, which is likely to have produced the burnt flavour, may have been masked (visually) by the natural dark colour of the bar.

In its current form and packaging this product is not suitable for inclusion in CR. High barrier packaging may reduce moisture migration and assist in retaining a moist, softer texture. An acceptable product will be one that is stable at higher-than-normal temperatures. Product reformulation and/or innovative processing techniques may aid in providing product stability at extremes of temperature.

3.4.1.4 *Strawberry bar*

The COTS strawberry bar was placed on storage profile 2 (Table C1 and Appendix C) to assess stability following short-term storage at high temperatures.

Significant differences in the quality were found following ASLT. When stored at 37 °C, the mean ratings fell below 5 for appearance, flavour and overall acceptability after two months. Flavour and overall acceptability ratings were significantly ($p<0.03$) below AQL after six months. At 48 °C all attributes were unacceptable after one month, with ratings significantly ($p<0.006$) below initial values for texture, flavour and overall acceptability. After two months all attribute ratings were significantly ($p<0.02$) below the AQL. All attributes significantly ($p<0.04$) declined after two weeks and fell significantly ($p<0.03$) below AQL after one month at 55 °C. NEB directly influenced aroma, appearance and flavour ratings. Textural changes due to moisture migration were also evident.

This COTS product was not anticipated to comply with SL requirements. Flavour and overall acceptability fell below AQL after only six months at 30 °C. The level of deterioration during ASLT rendered it unacceptable—the bar became hard and dry, darkened in colour and developed a burnt flavour. High barrier packaging may reduce moisture migration and assist in retaining a moist, softer texture. An acceptable product will be one that is stable at higher-than-normal temperatures. Product reformulation

²⁵ This product has previously been found to meet ADF SL requirements when stored at ambient temperatures (unpublished data, DSTO-Scottsdale).

and/or innovative processing techniques may aid in providing product stability at extremes of temperature.

3.4.2 Confectionery

The concept ration contained two COTS products, one COTS product in MOTS packaging and one current CR component (chocolate). Ration chocolate was excluded from ASLT trials as it was already a CR component and meets SL requirements. Confectionery products placed on storage were high in sugar, and increasing the storage temperature was expected to exponentially increase the rate of NEB.

None of the COTS products met SL requirements. NEB directly and adversely influenced appearance and flavour. Textural changes due to moisture migration were also evident. The commercial packaging material was a polymer laminate (which does not provide high barrier protection against moisture). In MOTS packaging, each product would have real potential for inclusion in CR.

3.4.2.1 *Soft panned confectionery, orange flavour*

The orange-flavoured SPC was placed on two storage profiles. This served to assess stability following short-term storage at high temperatures (profile 2 of Table C1 and Appendix C) and over longer periods at more enduring temperature conditions (profile 3).

Mean and median results fell below the AQL for texture after storage for 18 months at 30 °C, 12 months at 37 °C and three months at 48 °C. Overall acceptability ratings also fell below acceptable levels after 24 months at 30 °C. Product hardening was the major contributor to quality loss. The onset of NEB was also noted. In all instances the ratings following storage were significantly different ($p < 0.001$) from, and below the initial ratings.

Significant differences in the quality were also found following ASLT. When stored at 37 °C, the rating for appearance significantly ($p < 0.004$) reduced after four months, however it remained acceptable for the 6 month storage period. At 48 °C, significant ($p < 0.002$) decline in appearance, texture and overall acceptability were evident after two months, with mean rating falling significantly ($p < 0.02$) below AQL after four, three and three months respectively. All attributes declined significantly ($p < 0.001$) and were below AQL after one month at 55 °C.

SPC has a limited life (potentially only 2–4 weeks) when stored at extremely high temperatures (55 °C). However, at temperatures of 48–50 °C shelf stability was found sufficient to meet Defence requirements.

Long-term storage under warranty conditions, while not achieved, may be achievable with the application of high barrier packaging to delay hardening (moisture loss). Further evaluation of SL is warranted for soft panned confectionery in high barrier packaging. If repackaging is a success, the onset of NEB will be the next hurdle to overcome in achieving product stability and acceptability.

3.4.2.2 *Soft panned confectionery, lemon/lime flavour*

To assess whether an alternative flavour may have a different survival rate under real time storage conditions, the lemon/lime SPC was placed on storage profile 3 (Table C1 at Appendix C).

Mean and median results fell below the AQL for all attributes after storage for 18 months at 30 °C, 12 months at 37 °C and two months at 48 °C, with texture failing after only 12 months at 30 °C. Ratings for overall acceptability were significantly ($p<0.04$) below AQL following 24 months at 30 °C and 12 months at 37 °C. Product hardening was the major contributor to quality loss. Taste panellists did not mention detecting a burnt flavour (which was expected to occur as a result of NEB). In all instances the ratings following storage differed significantly from ($p<0.003$) and were below those of the initial product.

While the SL of lemon/lime flavoured SPC was shorter than that of the orange flavoured product, it may have adequate SL (greater than 36 months) at 20 °C.

As applies to the orange flavoured SPC, the application of high-barrier packaging may improve the SL of the lemon/lime flavoured SPC.

3.4.2.3 *Hard panned fruit confectionery*

Hard panned fruit confectionery (HPFC) was placed on ASLT profile 2 (Table C1 of Appendix C) to assess stability following short-term storage at high temperatures.²⁶ MOTS packaging was used, affording higher barrier properties than applied to the COTS versions.

Significant differences in the quality were found following ASLT. When stored at 48 °C, although the flavour significantly ($p<0.015$) declined after two months, the product remained acceptable for five months. At 48 °C, significant ($p<0.015$) reduction in ratings for texture and overall acceptability were evident after three months, with mean ratings falling below AQL after four months. At 55 °C, although a significant ($p<0.04$) reduction was observed after one month, appearance and flavour remained acceptable for the duration. Significant ($p<0.002$) reductions in texture and overall acceptability were also evident after one month at 55 °C, with mean ratings falling below AQL after one and two months respectively. Comments from panellists suggested the product hardened during storage, and some darkening in colour of the yellow HPFC occurred.

The SL of HPFC at temperatures in the range 48–50 °C is sufficient to meet Defence requirements. Quality attributes of HPFC remained unchanged ($p>0.66$) when stored at 30 and 37 °C for six months.

Based on these results, this product is potentially suitable for inclusion in CR. Real time SL studies are required to confirm that this product (in MOTS packaging) does meet SL requirements.

3.4.3 Dried fruit and nuts

The concept ration contained four COTS fruit and/or nut products in MOTS packaging – apricots, sultanas, banana chips and peanuts. As COTS products, none of these was considered likely to meet SL requirements. In MOTS packaging, it was predicted that each product would have the potential for inclusion in CR.

²⁶ This product has previously been found to meet ADF SL requirements when stored at ambient temperatures (unpublished data, DSTO-Scottsdale).

Although included in the concept pack as blends (with the exception of banana chips), each fruit and nut product was placed on storage as a single product to investigate the reactions and stability of each component in isolation. In addition, the peanut/sultana blend was stored as a multi-component product.

In general, COTS fruits fell short of SL requirements. Browning and moisture loss were the major reasons for loss of acceptability. The potential for alternative processing conditions to protect fruits from browning should be investigated. Fruits and nuts are popular jack rafter components. There is the potential to enhance nutritional status of ADF members through the inclusion of these food items in CR. Such items are not only energy dense, but also provide a number of essential, and sometimes limiting, vitamins and minerals.

3.4.3.1 *Sultanas*

Sultanas were purchased in bulk from a local wholesaler. They were reported to have a moisture content of ~15% and were of good commercial standard. They were re-packed into single serve (50 g) packets using a Department of Defence specified laminate – type XIV (Department of Defence, 2008). Sultanas were then placed on two storage profiles. This served to assess stability following short-term storage at high temperatures (profile 2 of Table C1 and Appendix C) and over longer periods at more enduring temperature conditions (profile 3).

Significant differences in quality were found following ASLT. When stored at 30 °C the product was stable for six months. At 37 °C, appearance, texture, flavour and overall acceptability ratings fell below AQL after four, twelve, four and four months respectively, with overall ratings becoming significantly ($p < 0.005$) different from initial product quality after six months. At 48 °C, appearance, texture, flavour and overall acceptability mean ratings fell below AQL after one, four, two and two months respectively, with flavour and overall rating being significantly ($p < 0.003$) different from initial values at this time. Flavour and overall acceptability ratings were significantly ($p < 0.005$) below AQL after three months. At 55 °C, texture remained acceptable. Appearance, flavour and overall ratings fell below AQL after two weeks, one month and one month respectively, with the latter two attributes being significantly ($p < 0.01$) lower at this time. By one month, all attributes (other than texture) were significantly ($p < 0.05$) below AQL. At high temperatures quality loss was found to be a result of product darkening and development of burnt flavours. Product hardening was also evident. Irrespective of storage temperature, texture ratings did not differ significantly from the initial values.

The SL of sultanas at temperature extremes (e.g. 48–50 °C) is limited. To some extent, improvements in packaging may aid in increasing SL, however browning is expected to be the major deteriorative process. Improved processing (including application of hurdle technology) may serve to increase SL.

Similar results were found when sultanas were stored under profile 3. Mean results fell below the AQL for flavour and overall acceptability after 18 months at 30 °C, eight months at 37 °C and two months at 48 °C. While comments on product texture suggested the product dried out, no significant differences in texture were observed. At high temperatures browning resulted in burnt flavour taints. Significant ($p < 0.05$) decline in flavour was observed after 12 months at 37 °C and three months at 48 °C, with mean results falling significantly ($p < 0.01$) below AQL.

Under the packaging and storage conditions that applied here, sultanas were found to be unsuitable for CR. Improvements to stability and SL may be achieved by optimal drying and processing of sultanas. The application of high barrier packaging to delay hardening (moisture loss) may further assist. It would be appropriate for Defence to persist with attempting to source a suitable sultana product for inclusion in CR.

3.4.3.2 *Apricots*

Apricots, whole, pitted were purchased in bulk from a local wholesaler. They were reported to have a moisture content of ~30% and were of good commercial standard. The apricots were re-packed into single serve (50 g) packets using a Department of Defence specified laminate—type XIV (Department of Defence, 2008). Apricot serves were placed on ASLT profile 2 (Table C1 of Appendix C) to assess stability following short-term storage at high temperatures.

Significant differences in the quality were found following ASLT. When stored at 37 °C for two months all sensory attributes fell below AQL and significantly ($p < 0.02$) declined from initial values. After four months, appearance, flavour and overall acceptability ratings were reduced significantly ($p < 0.002$) and were below AQL. After one month at 48 °C, mean ratings fell significantly ($P < 0.03$) below AQL and all results were significantly ($p < 0.001$) lower than initial values. At 55 °C, all attributes declined significantly ($p < 0.001$) and were significantly ($p < 0.02$) below AQL after only two weeks. The sultanas presented as a very dark to black product after only short periods at each of the elevated storage temperatures. The majority of the panel declined to taste the product when it was this colour.

The high moisture content of the COTS apricots facilitated early onset of browning. The use of a drier apricot product would increase shelf stability, and further investigation of apricots as a CR item is warranted. Dried fruits are energy-rich, high in fibre and provide essential micronutrients that alternative sweet snacks (such as confectionery) do not.

3.4.3.3 *Banana chips*

Banana chips were purchased in bulk from a local retailer. They were reported to have a moisture content of ~5% and were of good commercial standard. They were re-packed into single serve (40 g) packets using a Department of Defence specified laminate—type VI (Department of Defence, 2008) and vacuum sealed. Being a fried product it was considered necessary to protect the banana chips from oxygen to limit the onset of oxidation. With browning being of secondary concern they were placed on storage profile 1 (Table C1 and Appendix C) to assess stability over long storage periods at more enduring temperature conditions, where rancidity was likely to occur.

No significant change in product quality was observed when stored at 20, 30, 37 or 48 °C. All sensory attributes remained acceptable throughout the storage trial. Under the conditions of packaging and storage used in this trial, banana chips were found suitable for inclusion in CR. Unfortunately, the process of vacuum-packing may be prohibitively expensive. However, it was clear that stability can be achieved, so evaluation of other modified atmosphere packing techniques is warranted. Banana chips are nutrient-dense and rich in dietary fibre, potassium and other essential nutrients. Their inclusion in CR would very likely be well received by ADF members.

3.4.3.4 *Hi-oleic peanuts*

Hi-oleic peanuts (oil-fried and salted) were sourced in bulk directly from an Australian manufacturer/supplier. They were re-packed as single serve (40 g) sachets in laminate type XIV (Department of Defence, 2008b). Hi-oleic peanuts (which are rich in relatively stable mono-unsaturated fat) are reported to have a SL up to 10 times greater than normal peanuts (which are rich in relatively unstable poly-unsaturated fat). Being an oil-fried product and naturally high in oil, rancidity was considered the likely primary mode of deterioration. Therefore, this product was placed on storage profile 1 (Table C1 and Appendix C) to assess its stability over long storage periods at more enduring temperature conditions, where rancidity was likely to develop.

The appearance and texture of this product remained acceptable throughout storage and no significant changes in these attributes were observed. At 30 °C, flavour and overall acceptability ratings fell below AQL, with a significant ($p<0.05$) decline in flavour observed after 18 months. Flavour and overall acceptability ratings had significantly ($p<0.01$) declined (and were below AQL) after eight months at 37 °C. At 48 °C, mean ratings fell below AQL for flavour and overall acceptability after three months. Rancidity was the major reason for the decline in ratings.

Under the conditions of packaging used in this trial, high-oleic peanuts were not found to be suitable for inclusion in CR. However, the application of nitrogen flushing would reduce oxygen levels in the headspace of packages and would delay the onset of oxidation. In combination with high barrier packaging, this would likely deliver a peanut product that meets SL requirements.

Oil-fried and salted nuts were the most favoured products at focus group sessions and on this basis alone were chosen for inclusion in the concept pack. However, for shelf stability the honey roasted variety (also well-liked by focus groups) is now considered to be a more appropriate option for inclusion in CR. This variety is worthy of consideration for inclusion in CR.

3.4.3.5 *Sultana/peanut mix*

Focus groups reported a preference for fruit and nut mixes rather than dried fruit or nuts alone. Given that fruits and nuts are quite varied in chemical make-up and deteriorative processes, it was not expected that a mix would have suitable SL without careful consideration and processing. A mix was included as a single item in the concept pack and SL testing was conducted to investigate the extent and causes of reduced SL.

Hi-oleic peanuts (salted and fried)²⁷/sultanas²⁸ (5:4 blend) were packed as a 90 g single serve in ADFFS laminate type XIV (Department of Defence, 2008b). Packets of this mix were placed on ASLT profile 2 (Table C1 of Appendix C) to assess stability following short-term storage at high temperatures.

Significant differences in the quality were found following ASLT. When stored at 30 and 37 °C the product remained acceptable (and somewhat stable) for six months. At 48 °C, mean appearance, texture, flavour and overall acceptability ratings fell below AQL after

²⁷ Product quality and supply was as per that specified in 3.4.3.4.

²⁸ Product quality and supply was as per that specified in 3.4.3.1.

two, four, two and four months respectively, with attributes (other than texture) having significantly ($p < 0.01$) declined from initial values. At 55 °C, appearance and texture ratings fell below AQL after one month. Flavour and overall acceptability ratings fell below AQL after two weeks and showed significant ($p < 0.001$) reductions after one month. Appearance, flavour and overall acceptability rating were significantly ($p < 0.02$) below the AQL following three months at 48 °C and one month at 55 °C. At high temperatures quality loss was found to be a result of fruit darkening and development of burnt flavours. Peanut staling was also observed. The stability of sultanas was found to improve when packaged with nuts, in comparison to packs of sultanas only (refer section 3.4.3.1).

The blend of high-oleic peanuts and sultanas did not possess sufficient shelf stability for inclusion in CR. In hindsight, the decision to mix a salted nut with fruit was inappropriate. Both ADF personnel (in user acceptability studies) and DSTO personnel (involved in SL studies) did not like the combination of fruit and salty nuts.

A fruit/nut snack is worthy of consideration as a component of CR. As discussed in Section 3.4.3.4 of this report, a roasted (unsalted) nut variety such as honey roasted nuts will likely improve palatability and stability. Combined with drier (more stable) fruit varieties, this would probably achieve a favourable outcome.

3.4.4 Dried/processed meat products

The demographic of the DSTO sensory panel is quite different from that of the ADF. It has long been recognised that DSTO's largely female panel may be less likely to return favourable ratings for dried meat products than the typical young male ADF member. As such, results of storage for this product concept will probably have more value in understanding stability of the product during storage rather than likely consumption rates by ADF members.

3.4.4.1 *Steak bar*

The teriyaki-flavoured steak bar was placed on two storage profiles. This served to assess stability following short-term storage at high temperatures (profile 2 of Table C1 and Appendix C) and over longer periods at more enduring temperature conditions (profile 3).

Mean and median results fell below the AQL for appearance, flavour and overall acceptability after 12 months storage at 30 °C. A significant change in quality was not observed until 18 months when texture, flavour and overall acceptability ratings significantly ($p < 0.015$) declined from initial values. By 24 months, the ratings fell significantly ($p < 0.025$) below AQL. Product hardening was the major contributor to quality loss. Stored at 20 °C, this product was found to be shelf stable for 36 months.

Significant differences in the quality were also found following ASLT. When stored at 30 °C for six months the appearance rating fell below AQL and was significantly ($p < 0.035$) different from the initial value. Other attributes remained stable for six months at 30 °C. When stored for six months at 37 °C, appearance and texture ratings fell below AQL and were significantly ($p < 0.02$) below their initial levels. Mean ratings for flavour and overall acceptability also fell below 5.0 after four months. The rating for overall acceptability dropped significantly ($p < 0.03$) below the initial value after six months. At 48 °C, significant ($p < 0.002$) decline in appearance, texture, flavour and overall acceptability were

evident after three, two, four and two months respectively, with ratings falling below AQL after two months for appearance, texture and flavour, and one month for overall acceptability. Results were significantly ($p<0.02$) below AQL after three, four, five and three months respectively.

Mean ratings fell below AQL for all attributes after one month at 55 °C and were significantly ($p<0.03$) less than initial values for texture, flavour and overall acceptability at that time. After two months, texture and overall acceptability ratings were significantly ($p<0.05$) below AQL. At high temperatures quality loss was found to be a result of product hardening and loss of flavour volatiles. Product darkening was also evident.

Steak bar products are unlikely to meet SL requirements for high-temperature storage (~50 °C), however they show potential to meet warranty requirements with some product improvement. Modifying sugar and/or fat profiles, lowering the free moisture content, and enhancing barrier properties of packaging are plausible options for product improvement to achieve SL requirements.

3.4.4.2 *Beef jerky*

Beef jerky was placed on ASLT profile 2 (Table C1 of Appendix C) to assess stability following short-term storage at high temperatures. This product was packaged in commercial packaging.

No significant changes in the quality were found following ASLT even though product mean ratings for appearance, texture, flavour and overall acceptability fell below AQL at the first sampling point of storage at 30, 37, 48 and 55 °C. This occurred because initial quality ratings were marginal at best—with the initial texture rating actually being below AQL. Flavour rating did not significantly drop below the AQL during this storage trial. Overall acceptability ratings were significantly ($p<0.05$) below the AQL following six months at 30 °C, four months at 37 °C, and one month at both 48 and at 55 °C. Jerky products are typically drier than steak bar products, therefore they are chewier and sometimes considered tough due to the dryness. The flavour was largely tainted by an overbearing saltiness. On storage, the major observed change was increased chewiness/toughness.

It is important to note that dried meat is likely to develop a burnt appearance and taste when stored at high temperatures. Some loss of flavour is also likely. Strong flavours such as pepper may mask early burnt notes better than unflavoured varieties, thereby effectively extending the SL. Improvements in processing are required to improve the texture and flavour profiles of the beef jerky. Innovations in high barrier materials and modified atmosphere packaging continue to find commercial application in dried meat packaging. Enhanced packaging may reduce moisture and oxygen related deterioration.

Should an optimised product become available, DSTO recommends that further SL trials be conducted using ADF personnel as a consumer panel to evaluate acceptability.

3.4.5 Sports gels

The concept ration contained three COTS products. Gels were typically high in sugar, and increasing the storage temperature was expected to exponentially increase the rate of NEB.

Each COTS product showed potential for inclusion in CR. The effects of NEB varied, however it did not significantly adversely affect the flavour profile during storage. Commercial packaging adequately preserved each product. As discussed earlier, the packaging design was considered by consumers to be poor, with resealable functionality highly desired.

3.4.5.1 *Apple cinnamon gel*

The COTS apple cinnamon gel was placed on storage profile 1 (Table C1 and Appendix C) to assess its stability over long storage periods at more enduring temperature conditions.

No significant differences in the quality were found throughout the storage program. Mean ratings for flavour and overall acceptability fell below the AQL of 5.0 after 12 months for all temperature treatments (20, 30, 37 and 48 °C). However, no result was significantly below the AQL. Initial ratings for flavour and overall acceptability were marginal at best, leaving little room for deterioration before becoming unacceptable. DSTO panellists did not identify any discernible changes in flavour profile during storage. The product was considered shelf stable.

If the product is acceptable to the consumer in COTS packaging, it is potentially suitable for inclusion in CR.

3.4.5.2 *Chocolate gel*

The COTS chocolate gel was placed on ASLT profile 2 (Table C1 of Appendix C) to assess stability following short-term storage at high temperatures. This product was packaged in commercial packaging.

Initial ratings by the DSTO panel were marginal at best—initial mean ratings for appearance and texture indicated fair quality (5.5–6.0), while the initial flavour and overall acceptability were below the AQL. No significant differences in the quality were found following ASLT. The panel found the flavour quite strong and somewhat chemical (metallic) in nature, a sensory attribute that ADF focus groups did not detect. In time, the chocolate flavour dissipated, with saltiness and bitterness predominating.

This product was found somewhat stable. If the product is acceptable to the consumer it is potentially suitable for inclusion in CR.

3.4.5.3 *Vanilla gel*

The COTS vanilla gel was placed on two storage profiles. This served to assess stability following short-term storage at high temperatures (profile 2 of Table C1 and Appendix C) and over longer periods at more enduring temperature conditions (profile 3).

No significant differences in the quality were identified when stored under profile 2. The product remained acceptable.

High-temperature ASLT studies led to noticeable changes in appearance, with ratings falling below AQL after three months at 48 °C and 1.5 months at 55 °C. This decline in appearance influenced the overall acceptability at 48 °C, with results falling significantly ($p < 0.05$) below AQL after six months for both appearance and overall acceptability.

In its commercial packaging the vanilla gel met the SL requirements. If the product is acceptable to the consumer, it is suitable for inclusion in CR.

3.4.6 Main meal items

The concept ration contained one COTS product (flour tortilla) and five current CR components (retorted meals, fish, sauce and savoury biscuits). The current CR items were excluded from ASLT trials as they were known to meet SL requirements. Confectionery products placed on storage were high in sugar, and increasing the storage temperature was expected to exponentially increase the rate of NEB.

The COTS packaging used for flour tortilla was expected to adequately preserve the product.

3.4.6.1 *Flour tortilla*

Flour tortilla was placed on ASLT profile 2 (Table C1 of Appendix C) to assess stability following short-term storage at high temperatures. By commercial standards this product was packaged for longevity. Two serves of round tortilla were packaged in laminated (12 µm PET/50 µm LLDPE) pouches, gas-flushed with N₂:CO₂ mix (80:20) and sealed with an oxygen scavenger enclosed. The supplier reported a commercial SL of 270 days at ambient temperature.

Significant differences in the quality were found following ASLT. The texture, flavour and overall acceptability significantly ($p < 0.001$) declined following six months storage at 30 °C, two months at 37 °C, one month at 48 °C and two weeks at 55 °C, with all ratings falling below the AQL. At these profiles, texture and overall acceptability ratings were significantly ($p < 0.04$) below the AQL, with significant failure following soon after for flavour. Comments from panellists indicated the quality loss was largely attributable to oxidation (rancidity) and texture change (drying out). Given the effort put into optimising the packaging and application of modified atmosphere techniques (gas flushing and oxygen scavenger) these results were very disappointing. The laminate material and/or packaging integrity were evidently inadequate to maintain product quality under these storage conditions.

When the bread product was received at DSTO concerns were raised with the supplier with regard to the residual life of the oxygen scavengers. The oxygen scavenger sachets were somewhat rigid in form, suggesting they may have been exhausted. In its current form this product is not suitable for inclusion in CR. Further investigation into high barrier packaging and improvements in seal integrity (for prevention of moisture loss and protection against oxygen ingress) is warranted.

Bread is a popular food, being commonly used as a jack ration item. It complements a main meal and increases the nutritional value and satiety of the CR. There is clearly value in including a form of bread within the ration design. Popularity will ultimately lead to increased consumption and ultimately increased nutrient intake. As a CR menu item Defence would have greater understanding of the extent to which this product improves overall nutrient intake from CR provisioning.

3.4.7 Beverages

The brew kit and sports drink powders were exempt from this trial, as all items were current CR components.

3.4.7.1 *Chocolate drink mix*

No significant changes in sensory quality were observed during storage. While the mean results for flavour and overall acceptability fell below the AQL after six months storage at 48 °C, they were not significantly different from initial levels. At high temperatures this product has proven suitable for CR. Long-term storage under more representative conditions is required to validate the suitability of this product in CR.

If the product is acceptable to the consumer, it is potentially suitable for inclusion in CR in its commercial packaging. A real-time SL study is warranted.

3.5 Further developments required to optimise LWED CR

As a result of this study, a number of potential improvements have been identified to improve on the design, configuration and SL requirements of the ration concept detailed herein. These include:

- A reduction in pack weight and volume is required to achieve the design requirement.
 - Current CR main meal items were included in this pack. Further improvement toward energy densification could easily be achieved by selecting main meal items with lower moisture content. The current CR items have high moisture (~60-80%). The use of intermediate moisture main meal items (~50%) could reduce the weight of the CR by a further 40 g per day.
- An assessment of the micronutrient content of the concept pack is required.
 - The nutrient profile for this concept pack only considered the macronutrients. As many of the items were COTS products, DSTO was not able to evaluate the micronutrient content of the prototype pack. Further work is required to determine micronutrient requirements for such a ration design and to assess the adequacy of this pack to meet these requirements. The IOM committee (2006) recommended a suite of guidelines for micronutrient composition in rations intended for short-term, high intensity combat operations. The guidelines took into account the negative energy balance of a soldier's daily nutrient intake, ensuring health and performance risks were mitigated.
- Micronutrient specifications are required for nutrient deficient special purpose rations.
- The amount of protein in the ration design is inadequate.
 - The LWED CR prototype delivered an average of 68 g of protein per day. The IOM, 2006 reported that sustaining on CR where there is a substantial negative energy balance (leading to a negative nitrogen balance) can result in muscle loss, fatigue and loss of performance. To minimise these potential

consequences, the IOM committee recommended a protein level of 1.2-1.5 g/kg of body weight per day, or 100-120 g protein per day.

- The nutrient intake was below the study's expectations. Consideration of alternate products (namely COTS food items) is required to increase nutrient intake.
 - The choice of bread used did not meet consumer requirements (readily crumbled and not product compatible). It also failed to offer a suitable SL.
- The SL of many COTS components was not adequate to meet current ADF requirements.
 - Current SL requirements are governed by the acquisition business model and supply chain for in-service CR. Specialised CR may not have the same SL requirements as current CR.
- Defence needs to define the capability and operational requirements for specialised CR
 - This will define the appropriate supply chain and ultimately the SL requirements for specialised CR components.
 - Business models for acquisition, other than that used for in-service CR, will better suit the inclusion of COTS components in CR.
- Alternative packaging configurations are required to address identified service suitability and current SL shortcoming.
 - A wide range of types of packaging are currently used in commercial food production. These materials largely affect the oxygen and water transfer during storage, and hence the SL of the product. In an attempt to improve the SL, several of the commercial products evaluated were and/or could be re-packaged with a high barrier plastic foil laminate, which would afford greater protection to the product from moisture and oxygen transfer.
 - By using appropriate packaging (materials and processes) it should be possible to increase the SL of susceptible foods. The use of high barrier packaging can prevent migration of oxygen and/or water through the packaging material. In combination with removal of initial headspace oxygen, rancidity as a deteriorative reaction can be avoided. If the moisture content is an important consideration for the stability, high barrier materials (beyond that common to commercial supply) can prevent products from drying out or caking. This is likely to be cost effective, but may preclude the use of commercially packaged items into CR.

Use of COTS products may not be possible for CR components if/where Defence specifications preclude their consideration. The retail market may not always be able to comply with military specific requirements necessary to achieve nutrition, robustness or storage life beyond that typical designed into retail consumer goods.

4. Conclusions

Specialised CR are required for short-term, high intensity operations. Such rations require balanced consideration of:

- the need to minimise load carriage
- environmental influences on product quality, service suitability and consumption rates
- delivery of essential nutrients, including energy, macronutrients and micronutrients.

The current user requirement does not specify such a CR. The following outputs from this study are relevant and appropriate for consideration in the user requirement for CR:

- a defined nutrient composition for CR appropriate for 72 hour specific operations
- identification of product concepts that provide specific functional and performance outputs to support overall menu design
- menu choices that deliver user and consumer needs for improved consumption and service suitability
- predicted SL of COTS components used in the prototype.

The prototype pack achieved (if not exceeded) weight and nutrient design requirements. This prototype LWED CR was largely achieved through the substantial inclusion of energy dense EOTM food components, many of which were COTS items. The trade-off in achieving light weight was ultimately a reduced nutrient content. The volume requirement was not however achieved. Several revisions are suggested in the body of this report to further reduce the volume of this prototype. The final design had no requirement for water to reconstitute food items (other than beverages) and no preparation was required to consume items other than beverages. The evening meals included in the prototype pack were palatable if consumed cold. All menu items were considered to have high organoleptic acceptability.

Table 6 summarises the findings of this study. There was a general liking for most food, beverage and ancillary items in an operational environment. With the exception of the chocolate flavoured gel and ration chocolate, all items had over 50% support in the 'like' direction. No item scored highly in the dislike direction. Attitudes towards serve size varied. For most food items the average response was either adequate or inadequate (that is, participants did not consider any item to be provided in excess of requirement. There was a general high consumption rate for food items. The provisioning of EOTM food items likely influenced higher consumption rates. Consumption of gels and beverages (sports drink, coffee and tea) was variable with partial consumption most frequent.

Ration discard rates, although less than for previous studies of CR consumption in the field, were still high and further improvements are required to increase consumption when if reduced-energy CR are to be the basis of rationing in the short term.

Table 6 Product achievement against key performance indicators

Product	Focus group endorsed	Likeability	Portion size	Consumption	Predicted SL (months at 30 °C)
Apple/strawberry slice	100%	3.2	2.1	97%	12
Apple bar	N/A	3.5	2.2	96%	N/A
Fruit, nut cereal bar	N/A	N/A	N/A	N/A	6
Chocolate bar	90%	3.9	2.4	97%	12-18
Strawberry bar	95%	3.8	2.3	97%	6
Soft panned confectionery, lemon/lime	95%	4.6	2.7	100%	18
Soft panned confectionery, orange	89%	4.6	2.7	100%	18
Hard panned fruit confectionery	84%	4.3	2.5	98%	18
Ration chocodate	N/A	2.8	2.0	85%	N/A
Sultanas	80%	3.7	2.3	89%	12-18
Apricots	N/A	N/A	N/A	N/A	6
Banana chips	75%	3.7	2.1	87%	24
Hi-oleic nuts, oil fried and salted	85%	N/A	N/A	N/A	12-18
Sultanas/nuts mix	N/A	3.9	2.5	93%	12-18
Apricots/nuts mix	N/A	4.0	2.5	90%	N/A
Steak bar, teryaki	90%	4.7	2.9	100%	12-18
Beef jerky, original	75%	4.7	2.9	100%	6
BBQ chicken	N/A	3.4	2.2	88%	N/A
Tuna with dried tomato	N/A	4.4	2.7	100%	N/A
Chilli con carne	N/A	4.1	2.4	88%	N/A
Flour tortilla	N/A	4.3	2.9	95%	< 6
Sauce, sweet chilli	N/A	3.8	2.2	30%	N/A
Biscuit, savoury	N/A	4.5	2.7	97%	N/A
Sports drink powder, mixed berry	N/A	3.9	2.1	55%	N/A
Sports drink powder, lemon/lime	N/A	3.8	2.1	44%	N/A
Sports drink powder, tropical	N/A	3.0	2.1	35%	N/A
Gel, apple cinnamon	84%	3.1	2.2	82%	24
Gel, chocolate	85%	2.8	2.1	72%	24
Gel, vanilla	80%	3.2	2.2	70%	24
Chocolate drink - nutritional	N/A	3.6	2.2	90%	24
Chocolate drink - smoothie	N/A			78%	N/A
Coffee	N/A	4.1	2.6	58%	N/A
Tea	N/A	3.6	2.2	31%	N/A
Sugar	N/A	3.9	2.3	53%	N/A
Sweetened condensed milk	N/A	4.1	2.6	80%	N/A
Salt	N/A	3.6	2.1	7%	N/A
Pepper	N/A	3.6	2.1	9%	N/A
Spoon	N/A	4.6	2.1	N/A	N/A
Matches, waterproof	N/A	3.8	2.0	N/A	N/A
Matches, box	N/A	3.3	1.9	N/A	N/A
Scouring pad	N/A	3.2	1.8	N/A	N/A
Rubber bands	N/A	3.8	2.1	N/A	N/A
Toilet paper	N/A	4.2	2.2	N/A	N/A
Bags, resealable	N/A	4.2	2.3	N/A	N/A
Achieved (not significantly different from target)	Not achieved (not significantly different from target)				
Achieved (Significantly different from target)	Not achieved (Significantly different from target)				
N/A - not assessed					

Of the non-food items, the major finding was that insufficient toilet paper and resealable bags were provided. The spoon was found to be well liked. A small number of participants reported an excess of matches (boxed) and scouring pads, with both these items being the least liked of the non-food items. Future iterations of this ration design should consider making adjustments for these concerns.

The average energy consumed was 6487 kJ. This was 78.5% of the 8260 kJ provided, and was less than the target of at least 90% consumption. The effect of this on cognitive and physical performance is unknown was outside the scope of this study. Sugar was the least consumed of the measured nutrients. An over-supply of sweet products may have contributed to the unexpectedly low total energy consumption. Future improvements may include increasing savoury carbohydrates and decreasing sweet food items. This may improve overall energy consumption.

A number of short-comings were identified in the concept pack during this study (refer Section 4.5). These issues warrant consideration if this CR concept is to progress.

5. Recommendations

5.1 Introduction of specialised CR for short-term, high-intensity operations

- As the capability manager of CR, Army should consider including in the user requirement for CR scope for acquisition of a LWED CR to sustain Land Forces involved in high-intensity, short-duration operations.
- Army should consider integrating the findings from this study into the current user requirement for CR to expand the scope, functionality, capability and operational requirements for future CR.
- COTS items, with brand familiarity and high acceptance ratings, should be more widely used to improve overall nutrient intake and deliver essential nutrients.
- Army should collaborate with DSTO and other stakeholders to review, refine, justify and document the future capability and operational SL requirements for CR.

5.2 Refinement of the prototype LWED CR

It is recommended that DSTO be tasked to further investigate improvements to the functionality and performance of the prototype LWED CR. R&D should include:

- establishing micronutrient requirements of such a CR design
- increasing the amount of protein in the concept pack
- evaluating the adequacy of micronutrients in the prototype LWED CR
- reviewing commercially available food bars, confectionery, fruit and/or nut mixes, dried meats, savoury biscuits, sports gels, main meal items, drink powders and bread products to understand their availability, nutrient profile (and benefit), service suitability and SL; products found compliant with functional and performance requirements would then be considered for inclusion in future menus of a LWED CR
- evaluating consumer acceptance of a broad spectrum of COTS items, to allow recommendations to be made to Army on which products meet user and consumer expectations, nutrient profiles and SL requirements
- investigating novel and recent commercial developments in food packaging and preservation technologies that will likely support the through-life safety and quality of CR delivered to ADF members in training and on operations.

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Appendix A: Product Concepts Evaluated By Focus Group

Table A1 Energy bars; high protein and/or high CHO content

Product name/brand code	Flavour variant	Supplier code	Net wt (g)	Fat -total (g/100 g)	Fat –sat (g/100 g)	Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus group rating
1 ¹	very berry	A	65	11.0	2.1	28.6	38.3	18.9	1528	160	37
2	strawberry		60	10.5	2.5	23.0	48.2	26.9	1596	291	95
2	choc peppermint		60	11.1	4.8	21.8	49.3	23.6	1615	199	80
5 ¹	coconut rough	B	65	8.3	4.1	30.8	44.5	20.3	1590	110	45
5 ¹	choc mint		65	9.2	6.8	31.1	48.5	33.4	1695	110	80
5 ¹	choc malt		65	9.4	7.0	30.7	49.2	32.9	1721	110	100
6 ¹	chocoroma		50	10.2	7.1	37.0	27.6	18.2	1652	332	35
6 ¹	mocha		50	10.6	8.3	37.0	27.8	16.0	1634	324	10
6	berrylicious		50	7.2	4.3	20.4	29.7	20.5	1369	243	90
6	apricot delight		50	7.0	3.7	20.4	30.5	20.7	1317	242	25
7 ¹	caramel rough		100	12.2	8.4	45.1	9.5	8.2	1590	70	65
7 ¹	choc crunch		100	10.9	7.8	45.1	10.9	8.2	1497	70	75
9 ¹	chocolate	C	65	5.0	2.6	26.9	53.0	17.4	1540	170	90
10 ¹	fruit and nut		110	5.0	4.1	27.3	46.2	18.4	1436	100	5
11 ¹	strawberries and cream		60	8.1	7.3	33.6	28.6	18.5	1645	168	70
11 ¹	double chocolate		60	7.8	6.5	34.6	26.2	5.8	1575	190	80
11 ¹	tropical delight		60	7.8	6.4	33.6	29.1	19	1586	173	65
12 ¹	choc hazelnut		90	10.9	7.4	44.4	21	8.9	1480	310	55
12 ¹	choc banana		90	10.9	7.4	44.4	21	8.9	1480	310	45
12 ¹	choc berry		90	10.9	7.4	44.4	21	8.9	1480	310	50
13	apple strawberry		90	2.1	1.0	8.5	57.2	22.1	1230	340	100

Table A1 contd. Energy bars; high protein and/or high CHO content

Product name/ brand code	Flavour variant	Supplier code	Net wt (g)	Fat -total (g/100 g)	Fat –sat (g/100 g)	Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus group rating
14	cookies and cream	D	65	4.9	0.6	14	66	38	1580	140	70
14	raspberries and cream		65	4	0.8	8.5	69.3	34.3	1520	140	60
14	cappuccino		65		3.8	1.5	65	26	1540	140	60
14	vanilla crisp		65	3.5	0.8	13.9	62	31	1450	140	65
14	chocolate		65	3.1	0.8	15	65	22	1510	140	55
15 ¹	chocolate fudge brownie		65	8.7	5.7	28	32.2	23.4	1610	149	75
15 ¹	vanilla yoghurt		65	8.9	5.8	29.4	27.6	17.8	1640	169	60
15 ¹	cookies and cream		65	8.6	5.9	27.7	30.7	22.2	1650	157	65
19	chocolate	E					Data not available				70
21	chocolate	F	65	5.7	2.9	22.0	53.3	23.2	1522	150	60
21	choc coconut		65	11.0	9.0	24.0	53.0	27.0	1716	300	10
21	apricot		65	2.6	1.2	22.3	57.9	25.3	1448	180	35
21	berry		65	9.8	7.1	21.0	52.0	25.0	1774	-	10
22	vanilla	G	55	2.7	-	19.5	63.6	24	1509	98	70
24	chocolate	H	17	16.6	8.3	8.8	59.5	27.8	1780	300	50

¹ High protein (>25%)

Table A2 Confectionery

Product name/brand code	Supplier	Flavour	Net wt (g)	Fat -total (g/100 g)	Fat –sat (g/100 g)	Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus group rating
Licorice	I	-	bulk	2.7	1.2	0.0	54.7	43.8	1032	-	84
Hard caramels	J	-	50	9.2	8.1	0.3	86.1	66.0	1810	345	58
Hard panned confectionery	K	fruit, various	bulk	4.5	2.0	0.0	91.2	73.0	1720	44	84
Soft panned confectionery	L	lemon lime	28	<0.1	<0.1	<0.1	85.0	67.0	1390	214	95
		orange	28	<0.1	<0.1	<0.1	86.0	76.0	1399	214	89
Soft jubes	M	various	25	<0.1	<0.1	3.3	81.0	49.7	1440	152	74
Butterscotch	N	-	bulk	2.9	2.1	0.2	93.7	73.7	1704	340	37
Barley sugar		-	bulk	0.1	-	-	97.5	71.6	1662	90	68
Fruit drops		various	bulk	0.3	-	-	97.2	71.0	1664	90	47

Table A3 Freeze dried and dehydrated fruits

Product name/brand code	Supplier	Net wt (g)	Fat -total (g/100 g)	Fat –sat (g/100 g)	Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus group rating
Apple rings, evaporated	O					Data not available				40
Apricot pieces	P					Data not available				70
sultanas						Data not available				80
Apple pieces						Data not available				15
Apple, freeze dried	Q					Data not available				55
Banana, freeze dried						Data not available				0
Strawberries, freeze dried						Data not available				70
Pear, freeze dried						Data not available				10
Grapes, freeze dried						Data not available				75
Banana chips	R	50	27.5	24.3	1.5	66.0	31.0	2170	20	75

Table A4 Nuts

Product name	Supplier	Flavour variant	Net wt (g)	Fat -total (g/100 g)	Fatty acid profile (g/100 g)				Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus group rating
Peanuts	S	salty crunchy	50	53.8	9.4	<1	26.2	18.2	20.8	15.5	3.9	2650	410	95
		honey roasted	50	47.5	7.6	<1	35.3	4.6	28.4	12.5	14.8	2500	300	90
Peanuts, hi-oleic	T	roasted	bulk	48.4	-	-	-	-	29.8	11.1	-	2541	<5	65
		oil fried and salted	bulk	47.7	7.0	-	-	-	26.8	19.3	-	2470	-	95
		honey roasted	bulk	42.2	6.4	-	-	-	-	20.6	17.4	2310	314	90
		butterscotch and caramel	bulk											85
		honey and ginger	bulk											10
		tomato and herb	bulk											65
		cajun	bulk						Data not available					35
		chilli and lime	bulk											55
		malaysian curry	bulk											15

Table A5 Dried/processed meat products

Product name/ brand code	Supplier	Flavour variant	Net wt (g)	Fat -total (g/100 g)	Fat-sat (g/100 g)	Protein (g/100 g)	CHO (g/100 g)	Sugar g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus group rating
25	V	salami	15	30.9	13.1	25.0	3.5	0.5	1640	1683	45
26			15	35.7	15.5	26.7	3.5	0.5	1570	1839	50
Beef jerky	U	original	25	7.0	3.1	47.8	7.3	7.3	2300	1187	75
		hot & spicy	25	7.0	3.1	47.8	7.3	7.3	2300	1187	50
Steak bar	W	peppered	25	1.8	<1	50.0	17.8	10.7	2145	1200	65
		teriyaki	25	1.8	<1	50.0	17.9	17.9	1715	1200	90
Beef jerky	W	original	25	1.8	<1	53.6	10.7	10.7	2110	1200	55
		peppered	25	1.8	<1	50.0	17.9	10.7	2145	1200	25
		sweet and hot	25	1.8	0.5	50.0	17.9	14.3	1860	1200	60
		teriyaki	25	1.8	<1	50.0	17.9	17.9	1715	1200	55
		jalapeno				Data not available					15
Beef nuggets	W	original	50	3.0	1.5	38.0	18.0	18.0	2032	1012	75
		peppered	50	3.0	1.5	38.0	18.0	18.0	2032	1012	25
		teriyaki	50	3.0	1.5	38.0	18.0	18.0	2032	1012	60

Table A6 Sports/energy gels

Product name/ brand	Supplier	Flavour variant	Net wt (g)	Fat -total (g/100 g)	Fat-sat (g/100 g)	Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus Group rating
Gel	D	chocolate	41	5	2	<1	63.0	13.1	1225	110	85
		tropical fruits	41	0	0	<1	65.6	26.2	1120	37	70
Gel	E	vanilla	35	0	0	<0.1	74.3	29.4	1269	104	80
		citrus	35	0	0	<0.1	74.3	29.4	1269	104	80
Sports gel	G	lemon/lime	35	0	0	0	57.1		911	86	20
		espresso	35	0	0	0	57.1		911	86	65
		vanilla	35	0	0	0	57.1		911	86	50
Gel	X	apple cinnamon	41	0	0	0	66.0	7.0	1120	122	84
		peach banana	41	0	0	0	66.0	7.0	1120	122	58
		strawberry kiwi	41	0	0	0	66.0	7.0	1120	122	53
Gel	Y	lemon/lime	45	0	0	0	71.0	0.0	1200	267	5
		grape	45	0	0	0	71.0	0.0	1200	267	10
		peach	45	0	0	0	71.0	0.0	1200	267	10
Gel	Z	apple-cinnamon	36	0	0	0	63.8	5.6	1054	75	50
		vanilla	36	0	0	0	63.8	5.6	1078	75	25
		chocolate	36	0	0	0	61.1	5.6	1013	58	45
		orange	36	0	0	0	63.8	5.6	1055	64	50
Energy gel	AA	banana blitz	32	0	0	0	78.1	12.5	1313	125	65
		just plain	32	0	0	0	78.1	9.4	1313	125	65
		orange burst	32	0	0	0	78.1	9.4	1313	141	55
		vanilla bean	32	0	0	0	78.1	9.4	1313	125	75
		tri berry	32	0	0	0	78.1	9.4	1313	141	55
Gel	AB	gold	37	0	0	0	78.0	78.0	1358	139	40
		ginsting	37	0	0	0	78.4	78.4	1358	139	15
		chocolate	37	0	0	0	78.0	78.0	1358	139	15
		strawberry	37	0	0	0	78.4	78.4	1358	139	60
Energy gel	AC	summer fruits	38	0	0	0	60.0	18.0	1011	105	25
		juicy orange	38	0	0	0	60.0	18.0	1011	105	20
		citrus burst	38	0	0	0	60.0	18.0	1011	105	20
		banana blast	38	0	0	0	60.0	18.0	1011	105	40

Table A7 Processed fish products

Product name	Supplier	Flavour variant	Net wt (g)	Fat -total (g/100 g)	Fatty acid profile (g/100 g)				Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus group rating
					sat-	trans-	mono-	poly-						
Tuna steaks	AD	lemon pepper	150	2.6	0.5	0.1	0.6	1.4	28.1	0.4	0.4	575	370	95
Tuna	AE	lemon and black pepper	150	1.4	0.9	<0.1	0.4	0.1	24.5	3.5	1.2	528	850	84
		sweet chilli sauce	150	0.9	0.3	-	-	-	21.7	7.2	6.2	525	550	89
Tuna chunks	AF	plain	85	0.6	0.2	0.0	0.1	0.2	21.6	0.0	0.0	390	295	63
Tuna		sweet thai chilli	85	0.7	0.3	0.0	0.2	0.0	21.1	8.0	6.3	520	440	100
Salmon	AG	mild red chilli	100	11.8	4.1	<0.1	3.5	4.2	20.6	2.7	1.5	830	530	74
		lime and cracked pepper	100					Data not available						63
		oven dried tomato and capsicum	100	7.8	2.1	-	-	-	19.4	0.2	0.2	622	403	63

Table A8 Protein drink powders

Product name/ brand code	Flavour variant	Supplier code	Net wt (g)	Fat -total (g/100 g)	fatty acid profile (g/100 g)				Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)	Focus Group rating	
					sat-	trans-	mono-	poly-							
8	vanilla	B	bulk						Data not available					16	
8	chocolate		bulk							Data not available					11
3	chocolate	A	bulk	11.0	1.8				29.5	38.8	23.8	1660	116	5	
3	strawberry		bulk	11.0	1.8				29.5	38.8	23.8	1660	116	16	
4	-		bulk							Data not available					0
27	strawberry cream	AG	90	5	2.6	0	-	-	58.9	31.1	5.6	1587	344	84	
27	chocolate cream		90							Data not available					68
27	vanilla cream		90							Data not available					63
28	chocolate	AH	95	3.9	1.3				55.3	30.3	3.9	1487	461	26	
29	strawberry		bulk							Data not available					47
30	vanilla nougat	AI	bulk						Data not available					53	
30	chocolate nougat		bulk							Data not available					32
31	vanilla crème		bulk							Data not available					0
32	chocolate		bulk							Data not available					26

Table A9 Products not evaluated but included in LWED CR concept menu

Product name/brand code	Flavour variant	Supplier code	Net wt (g)	Fat -total (g/100 g)	Fat-sat (g/100 g)	Protein (g/100 g)	CHO (g/100 g)	Sugar (g/100 g)	Energy (kJ/100 g)	Na (mg/100 g)
Food bar	apple	AK	60	5.0	0.8	16.7	65	36.7	1540	50
	fruit, cereals and vitamins	AK	35	9.0	1.2	6.0	63	36	1440	42
Energy drink	-	D	25	10	7.1	13	66.3	46.4	1750	100
Smoothie	-	D	35	8.5	5.1	9.9	65.0	32.8	1670	145
Flour tortilla	-	AJ	54	8.9	4.4	7.0	49.4	3.9	1310	518

Appendix B: Questionnaire

72-hour Light Weight Combat Ration Pack (72-h LWCRP)

DSTO-Scottsdale is evaluating a prototype combat ration pack designed for the operational activities undertaken by 3RAR. To ensure this pack meets your needs, we ask for your feedback. As you are a frequent user of ration packs you are the best person to help us create future operationally specific rations.

Instructions

For each question, select your answer by colouring in the circle completely using blue or black pen. If you make a mistake, put a **X** through the first answer, and colour in the correct answer (see below).

Example



There are also some questions that require you to write an answer in your own words.

In each table, indicate how much you like each item by rating it 1 to 5. If you discard or trade the item, leave the 1 to 5 rating blank. You will be asked later to identify discarded/traded items.

In the example below, the respondents opinions are:

Lamb Casserole - They Love it, Enough provided

Sugar - They have no opinion and there is too much of it

Example	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
Lamb casserole	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Sugar	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

First we need some background information to help when we are analysing the data.

Your Full Name _____

Your Age _____ Years in service _____

In the past year, how many days in TOTAL was CRP your major source of food?

- ☐ 1-2 weeks
- ☐ 3-4 weeks
- ☐ 2-3 months
- ☐ 4-6 months

Section 1 - Acceptability of individual items in 72-hr light weight ration

Think about your experience eating each item during EXTS07, and give your opinion on how much you liked each item. Then comment on the adequacy of the serving size provided.

Bars/Slices	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
█████ slice, apple/strawberry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
█████ sport bar, apple	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
█████ chocolate bar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
█████ food bar, strawberry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Fruit and nuts	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
Peanuts/sultanas mix	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Peanuts/apricots mix	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sultanas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Banana chips	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Sports gels	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
█████ energy gel, apple/cinnamon	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
█████ gel, chocolate flavour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
█████ energy gel, vanilla	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Dried meats	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
Steak bar, teriyaki	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Beef jerky, original	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Confectionery	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
beans, orange	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
beans, lemon/lime	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
HPFC	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ration chocolate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Evening meals	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
BBQ Chicken	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tuna with dried tomato	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chilli con carne	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Bread & biscuits	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
Tortilla bread	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Biscuit, Vitalife cracker	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Beverages	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
Sport electrolyte drink, mixed berry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sport electrolyte drink, lemon/lime	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sport electrolyte drink, tropical	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
smoothie	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Coffee, instant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tea, bag	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sweetened condensed milk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Condiments & other	Overall liking					Amount provided		
	Hate it	Dislike it	No opinion	Like it	Love it	Too much	Enough	Not enough
Sauce, sweet chilli	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sugar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Salt	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pepper	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Spoon	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Matches, waterproof	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Matches, box	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pads, scouring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rubber bands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Toilet paper	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bags, resealable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For any item you did not like, please explain how it could be improved.

Section 2 - Preparation and ease of use

Think about your experience eating each item during EXTS07 and give your opinion on how easy each item was to prepare and how easy it was to clean-up afterwards.

For each of the items listed below, please indicate how they were prepared and consumed.

	Ate directly from packaging	Removed from packaging and ate without preparation	Removed from packaging and prepared before consuming
Sports drink powders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sports gels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Coffee/tea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
████ food smoothie	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Retort meals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tuna, pouched	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dried meat products	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bars and slices	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Confectionery and chocolate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fruit and/or nut mixes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For those items that were prepared before eating, please detail how they were prepared. Perhaps they were heated, hot or cold water was added or they were combined with other items in the pack.

Please detail any issues you had with cleaning up following preparation and consumption. This may include stickiness/seepage from packaging, rinsing cup canteen, lack of water for rinsing, etc.

Section 3 - Overall Ration Pack Design

In answering the following questions, please consider the overall experience of having eaten the 72-h LWCRP as the sole source of sustenance for a 72-h period.

How would you rate the following ration design issues?	Too much	Manageable	Ideal	Where less than manageable, please comment on how to improve.
Weight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<hr/>
Size/bulk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<hr/>
Amount of water required to reconstitute	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<hr/>
Packaging and other waste	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<hr/>

Did you take any jack rations on this exercise? This includes items from other CRP and those available commercially.

No ☐ If yes, please list.

Yes ☐

Please list any items you gave to others during this trial

Please list any items you received and consumed from others.

Please answer the following questions relating to WATER carriage, consumption and re-supply.

How many litres of water were you carrying when you boarded the aircraft?

1 L ☐ 2 L ☐ 3 L ☐ 4 L ☐ 5 L ☐ 6 L ☐ 7 L ☐ 8 L ☐ 9 L ☐ 10 L ☐ > 10 L ☐

How many litres did you consume during the flight?

1 L ☐ 2 L ☐ 3 L ☐ 4 L ☐ 5 L ☐ 6 L ☐ > 6 L ☐

Did you get any re-supply during the 72-h period?.

Yes ☐ If yes, please specify how many litres

No ☐

How many litres of water, including beverages, did you consume during each 24-h period.

	1 L	2 L	3 L	4 L	5 L	6 L	> 6 L
Day 1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Day 2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Day 3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please select any/all items in the following list that you think WOULD be suitable for inclusion in a light weight ration pack.

Yes **If yes, please provide details of brands, flavours, etc if you prefer others to those in this pack**

Dried beef products	<input type="radio"/>	_____
Tuna	<input type="radio"/>	_____
Freeze Dried Meals	<input type="radio"/>	_____
Retort meals	<input type="radio"/>	_____
Condiments eg. sauces, spices	<input type="radio"/>	_____
Trail mixes e.g Fruit & Nut	<input type="radio"/>	_____
Salted nuts	<input type="radio"/>	_____
Dried fruit e.g apricots, mango	<input type="radio"/>	_____
Savoury Biscuits - (eg BBQ Shapes)	<input type="radio"/>	_____
Bread e.g pita bread, pocket bread	<input type="radio"/>	_____
Fruit e.g tinned, pouched	<input type="radio"/>	_____
Breakfast cereal e.g muesli	<input type="radio"/>	_____
Breakfast cereal bars	<input type="radio"/>	_____
Sports bars e.g. protein bars	<input type="radio"/>	_____
Sports gels	<input type="radio"/>	_____
Sports Drink Powders	<input type="radio"/>	_____
Protein Shakes	<input type="radio"/>	_____
Coffee/tea	<input type="radio"/>	_____
Sweetened condensed milk	<input type="radio"/>	_____
Dried milk powder	<input type="radio"/>	_____
Sweets/confectionery	<input type="radio"/>	_____
Ration chocolate	<input type="radio"/>	_____
HPFC	<input type="radio"/>	_____

Thank you for taking the time to complete this survey

Appendix C: Shelf Life Evaluation of Commercial Components

Table C1 Storage profiles for SL evaluation

Temp (°C)	Time (months on storage)														
	initial	0.5	1	1.5	2	3	4	5	6	12	18	24	30	36	
1-4	✓✓				✓		✓		✓	✓		✓		✓✓	
20										✓✓	✓	✓✓	✓	✓✓	
30									✓✓✓	✓✓	✓✓	✓✓			
37					✓		✓✓✓		✓✓✓	✓✓					
48			✓✓✓		✓✓✓	✓✓✓	✓	✓	✓						
55		✓	✓	✓	✓										

Indicates points in the storage trial at which samples were removed for testing.

✓ Profile 1

✓ Profile 2 (6 month ASLT)

✓ Profile 3

Table C2 Storage profiles for each component evaluated

Product	Packaging	Storage profile
<i>Food bars</i>		
Chocolate	Commercial (metallised film)	2
Apple	Commercial (metallised film)	2
Strawberry	Commercial (metallised film)	2
Apple/strawberry slice	Commercial (metallised film)	1
<i>Confectionery</i>		
Soft panned confectionery, lemon lime	Commercial (clear material)	3
Soft panned confectionery orange	Commercial (clear material)	2,3
Hard panned fruit confectionery	MOTS, ADFFS laminate type XIV	2
<i>Dried fruits and nuts</i>		
(Hi oleic) peanuts oil fried and salted/sultana mix	MOTS, ADFFS laminate type XIV	2
Apricots, while pitted, dried	MOTS, ADFFS laminate type XIV	2
Sultana	MOTS, ADFFS laminate type XIV	1, 2
Banana chips	MOTS, FD meal pouch laminate	1
(Hi oleic) peanuts, oil fried and salted	MOTS, ADFFS laminate type XIV	1
<i>Dried meats</i>		
Steak bar, teriyaki	Commercial, foil and polymer laminate	2, 3
Jerky, original	Commercial, polymer laminate	2
<i>Sports gels</i>		
Apple cinnamon	Commercial, foil and polymer laminate	1
Chocolate	Commercial, foil and polymer laminate	2
Vanilla	Commercial, polymer laminate	1, 2
<i>Evening meal items</i>		
Flour tortilla	Commercial, clear polymer laminate, with oxygen scavenger	2
<i>Beverages</i>		
Chocolate drink mix	Commercial, foil and polymer laminate	2

Appendix D: Component Choice and Delivery: Further Justification

Product	Considerations	
Meal 1 Eat-on-the move' Light breakfast		
Food Bar	<ul style="list-style-type: none"> + CHO-vs-protein delivery, achieving balance of energy delivery + Provide variety through compressed bars and cake/slice presentation + Provide appetising/appealing "natural looking" products 	<ul style="list-style-type: none"> + Convenience + High satiety
Sports Electrolyte Drink	<ul style="list-style-type: none"> + Replace electrolytes from sweat loss + Used to refuel and rehydrate in the field 	<ul style="list-style-type: none"> + Current CR item
Meal 2 Eat-on-the move' energy supplement, single serve		
Confectionery	<ul style="list-style-type: none"> + Popular product (focus group collective agreement) + Convenient, eat-on-the-go + Instant source of energy 	<ul style="list-style-type: none"> + Portion size + Provide flavour variety
Meal 3 Eat-on-the move' trail mix, single serve		
Fruit/nut mix	<ul style="list-style-type: none"> + Popular item (focus group collective agreement) + Convenient, compact, energy dense + Suitable size to carry in webbing or pockets 	<ul style="list-style-type: none"> + Nuts provide high satiety + Currently used as jack rations
Meal 4 Eat-on-the move' lunch meal		
Dried meat or banana chips	<ul style="list-style-type: none"> + Popular items (focus group collective agreement) + Convenient, compact, energy dense + Suitable size to carry in webbing or pockets 	<ul style="list-style-type: none"> + High satiety + Good source of protein + Currently used as jack rations
Chocolate	<ul style="list-style-type: none"> + Ration chocolate current CR item + Good source of protein and carbohydrate + Suitable size to carry in webbing or pockets 	<ul style="list-style-type: none"> + Convenient, compact, energy dense
Meal 5 Eat-on-the move' Sports Gel		
Gel	<ul style="list-style-type: none"> + Popular product (focus group collective agreement) + Used to refuel and rehydrate in the field + Suitable size to carry in webbing 	<ul style="list-style-type: none"> + Include a variety of flavours

Meal 6 Substantial evening meal, Some (little) preparation permitted, palatable cold, pouched product with

Retort meal product	+ Current CR components	+ Palatable cold
	+ More popular of the current CR retort meal option	
Biscuit or bread adjunct	+ Substantiates a main meal-increasing the nutritional value and the level of satiety	+ Food compatibilities
	+ Biscuit, multigrain current CR component	

Meal 7 Beverage, high protein (food) drink

Chocolate drink	+ Popular item	+ Portion size
	+ Use for supper	+ Good brand name

Common and ancillary items

Chilli Sauce	+ Current CR components	+ More popular condiment
	+ Additional flavour to evening meal day 2	+ Compatibility
Brew kit and condiments (Sweetened Condensed Milk, Sugar, Coffee, Tea, Salt, Pepper)	+ Current CR components	
Non-food Items (Spoon, matches, Scouring pad, Rubber bands, Toilet paper)	+ Current CR components	
	+ Provide essential support to feeding system	

Appendix E: Light Weight Energy Dense Combat Ration Concept

Table E1 Menu sheet²⁹

Day 1		Day 2		Day 3	
	Quantity		Quantity		Quantity
Apple/strawberry slice	1 x 90 g	Apple bar	1 x 60 g	Strawberry bar	1 x 60 g
Sports drink powder, mixed berry	1 x 70 g	Sports drink powder, lemon/lime	1 x 70 g	Sports drink powder, tropical	1 x 70 g
Soft panned confectionery, orange	1 x 28 g	Hard panned fruit confectionery	1 x 60 g	Soft panned confectionery, lemon/lime	1 x 28 g
Peanut/sultana mix	1 x 90 g	Peanut/apricot mix	1 x 90 g	Sultanas	1 x 50 g
Steak bar, teriyaki	1 x 25 g	Beef jerky, original	1 x 25 g	Banana chips	1 x 40 g
Ration chocolate	1 x 50 g	Ration chocolate	1 x 50 g	Chocolate bar	1 x 65 g
Gel, apple cinnamon	1 x 41 g	Gel, chocolate	1 x 41 g	Sports gel, vanilla	1 x 35 g
BBQ chicken	1 x 250 g	Tuna with dried tomato	1 x 85 g	Chilli con carne	1 x 250 g
Tortilla bread	1 x 54 g	Biscuits, savoury	1 x 42 g	Tortilla bread	1 x 54 g
		Sauce, sweet chilli	1 x 10 g		
Chocolate drink mix	1 x 35g	Chocolate drink mix	1 x 25 g	Chocolate drink mix	1 x 35g
Accessory/Sundry pack					
Beverage, coffee, instant	3 x 3.5g	Salt	2 x 2 g	Matches	2 x Box
Beverage, tea bags	3 x 2.5g	Pepper, black	2 x 2 g	Pads, scouring, soaped	2 only
Sugar	6 x 3.5g	Spoons, dessert	1 only	Rubber bands	2 only
Milk, condensed, sweetened	1 x 85g			Toilet paper, 10 Sheets	2 x Pkt

²⁹ Items in black are current CR items. Items in blue are commercial items (not in CR at the time of ration concept realisation)

Table E2 Ingredient listing

INGREDIENT LIST 72 hour LW CR PACKED 2007

Day 1	Day 2	Day 3
Apple/strawberry slice	Apple bar	Strawberry bar
Organic flour, wholegrain wheat flakes , wholegrain rolled oats, wholegrain triticale flakes , oat bran, diced apples (4%), strawberry pieces (4%) [apple paste, strawberry paste, invert sugar, humectant (glycerol), vegetable gum (pectin) , food acid (296, 331), flavour], sultanas, soy fibre, rice fibre, whey protein isolate , brown sugar, water, soy protein, glucose, whole eggs , skim milk powder , L-carnitine, L-methionine, choline, bitartrate, inositol, L-phenylalanine , humectant (sorbitol), baking powder (450, 500), thickener (1422), emulsifier (E471, 475), salt, acid (citric acid), preservative (202, 281), flavours . Phenylketonurics: contains phenylalanine Warning: fruit pieces may contain preservative (220)	Maltodextrins, Milk Protein (Caseine), Glucose Syrup, Whole Milk , Tapioca Starch, Fructose Syrup, Ground Almonds , Oat Flakes , Malt Extract , Dextrose , Rice Starch, Egg Powder , Apple Fibre, Hazelnut Paste , Caramel (colour) , Artificial Flavours , added Vitamins [ascorbic acid (vitamin C), tocopheryl acetate (vitamin E), thiamine hydrochloride (vitamin B1), riboflavin (vitamin B2), Niacinamide (Vitamin B3), Vitamin B6], added minerals [Magnesium Aspartate, Potassium Aspartate].	Sultanas, Raw Honey , Ricemalt, Whey Protein Powder , Non GMO Soy Isolate , Cashews , Almonds , Multistain Lactobacillus Culture with Fructo-oligosaccharides , Pumpkin Seeds, Strawberry, Puffed Rice, Coconut, Rice Bran, Kiwifruit, Flaxmeal, Psyllium Husks, Tahini (Sesame Seeds) , Brazil Nuts , Skim Milk , Rice Protein, Dandelion Root, Papaya Aniseed, Ginger, Cinnamon, Beetroot, Strawberry Flavour (Nature Identical).
Beverage sports powder Type II mixed berry	Beverage sport powder Type II lemon/lime	Beverage sport powder Type II orange
Sugar, Dextrose , Citric Acid, Gum Arabic, Potassium Citrate, Salt, Ascorbic Acid (Vitamin C), Sodium citrate, Potassium Phosphate , Natural and Artificial Flavour (Blue 1), Sodium Phosphate, and Calcium Phosphate	Sugar, Dextrose , Citric Acid, Potassium Citrate, Salt, Ascorbic Acid (Vitamin C), Sodium citrate, Potassium Phosphate, Natural and Artificial Flavour , Sodium Phosphate, Calcium Phosphate, Cum Arabic and Artificial Colour (Yellow 5 and Blue 1)	Sugar, Dextrose , Citric Acid, Potassium Citrate, Salt, Ascorbic Acid (Vitamin C), Sodium citrate, Potassium Phosphate, Natural and Artificial Flavour , Sodium Phosphate, yellow 6 and Calcium Phosphate
Soft panned confectionery, orange	Hard panned fruit confectionery	Soft panned confectionery, lemon/lime
sugar, corn syrup, contains 2% or less of the following: natural flavor, thiamine hydrochloride (vitamin b1), riboflavin (vitamin b2), niacinamide (vitamin b3), ascorbic acid (vitamin c), citric acid, citrus pectin, potassium citrate, sodium citrate, sodium lactate, yellow 6, beeswax, carnauba wax, confectioner's glaze , salt manufactured in a plant that processes peanuts.	Sugar, Glucose syrup (sources include wheat) , vegetable fat , fruit juice (2.5%) , Food acids (330, 331) , Thickeners (dextrin, wheat maltodextrin), Flavours, Corn syrup, Colours (171, 110, 129, 102, 132, 133), Glazing agent (903). May contain peanuts, treenuts and milk products.	sugar, corn syrup, contains 2% or less of the following: natural flavor, thiamine hydrochloride (vitamin b1), riboflavin (vitamin b2), niacinamide (vitamin b3), ascorbic acid (vitamin c), citric acid, citrus pectin, potassium citrate, sodium citrate, sodium lactate, yellow 5, blue 1, beeswax, carnauba wax, confectioner's glaze , salt. manufactured in a plant that processes peanuts.
Peanuts/sultanas mix	Peanuts/apricots mix	Sultanas
HiOleic runner type peanuts , ssultanas, salt, peanut oil, vegetable oil.	Hi-Oleic runner type peanuts , salt, apricots, peanut oil	Sultanas, vegetable Oil
Steak bar, teriyaki	Chocolate	Banana chips
Beef, Sugar, salt, Soy sauce (water, wheat , soy beans , salt), Maltodextrin , flavour enhancer (E621), hydrolysed corn gluten , flavouring , antioxidant (E316), preservative (E202, E250), smoke flavour.	Cocoa Butter, Sugar, Dextrose , Skim Milk Powder , Cocoa Liquor, Oat Flour, Emulsifier (lecithin), Vitamins (Vitamin A, Thiamine & Vitamin C).	Banana, Coconut Oil, Sugar, Honey , Flavour.

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Chocolate ration Cocoa Butter, Sugar, Dextrose , Skim Milk Powder , Cocoa Liquor, Oat Flour , Emulsifier (lecithin) , Vitamins (Vitamin A, Thiamine & Vitamin C).	Beef jerky, original Beef, Dextrose , Salt, Sugar, Spices and Spice Extracts, , Hydrolysed Vegetable Protein Garlic Powder, Vegetable Oil , Flavour Enhancer (621) , Acidity Regulator (327), Antioxidant (316), and Preservative (250) .	Chocolate bar Glucose (from Tapioca), Invert Sugar (Glucose, Fructose), Maltodextrin (from Wheat) , Whey Protein Concentrate , Soy Protein Isolate , Calcium Caseinate , Oat Bran, Crisp Rice [Rice Flour, Malt Powder (from Barley), Wheat Starch, Salt, Emulsifier (471)], Humectant (glycerol), Fat Reduced Cocoa Powder (4%) , Chocolate Chips (1.5%) [Sugar, Vegetable Fat , Cocoa Powder, Milk Solids , Emulsifier (492) , Flavour], Citric Acid , Flavours , Creatine, Adenosine Tri-phosphate, L-Arginine, Glycine, L-Methionine, L-Leucine, L-isoleucine, L-Valine, Colours (133, 155). Warning: Product contains Gluten, Soy and Dairy Products and is made on a production line that also process products containing Peanuts and other Tree Nuts.,
Gel, apple cinnamon Maltodextrin , Water, Apple Puree (2%), Apple Concentrate (3%), Food Acids (330, 332), Sea Salt, Cinnamon, Preservatives (202, 211).	Gel, chocolate flavour Maltodextrin , fructose, water, chocolate liquor, humectant (422), slat, flavours , food acids (331, 338) , preservatives (202, 211) , mineral salt (508)	Gel, vanilla Purified Water, Maltodextrin , Fructose, Natural Flavour, Guar Gum , Xanthan Gum , Potassium Chloride, Sodium Chloride, Caffeine, Citric Acid, Sodium Benzoate (preservative), Potassium Sorbate (preservative).
BBQ chicken Cooked Diced Chicken with natural juices, Chicken Broth, BBQ Sauce (Sugar, Water, Salt, Soybeans , Honey , Maltose, Modified Corn Starch, Garlic, Wheat Flour Spices , Acidity Regulator (260), Colour (127)), Diced Red Capsicum, Diced Carrots, Onions, Corn, Modified Starch , Added Vitamins (Thiamine, Ascorbic Acid, Niacin, Riboflavin)	Tuna with oven dried tomato & basil Tuna, Water, Vinegar, Oven Dried Tomato, Vegetable Extract , Diced Tomato, Tomato Paste, Onion, Sugar, Salt, Basil, Natural Colour (Paprika Extract)	Chilli con carne Cooked Minced Beef with natural juices, Red Beans, Tomato Puree, Crushed Tomatoes, Onions, Modified Starch , Brown Sugar, Salt, Crushed Chillies, Seasonings, Added Vitamins (Thiamine, Ascorbic Acid, Niacin, Riboflavin)
Flour tortilla Wheat Flour , Water, Vegetable Oils [Antioxidant (306 Soy)], Sugar, Salt, Vegetable Gum (412) , Emulsifier (471), Mineral Salts (450) Food Acids (297), Mineral Salts (500), preservative (282), Wheat and Corn Flour , Preservative (200).	Cracker biscuit Wheat Flour , Grains (Wheat Meal , Kibbled Purple Wheat , Kibbled Red Wheat), Vegetable Oil , Bran, salt, fibre (Wheat , Oat, carob), Sunflower Seeds , Black Pepper, Sesame Seeds , Raising Agent (Baking Soda), Yeast, Milk Solids , sugar Vitamins (B1, B2, B3, B6, E & Folate), Mineral (Iron)	Flour tortilla Wheat Flour , Water, Vegetable Oils [Antioxidant (306 Soy)], Sugar, Salt, Vegetable Gum (412) , Emulsifier (471) , Mineral Salts (450) Food Acids (297), Mineral Salts (500), preservative (282), Wheat and Corn Flour , Preservative (200).
Chocolate drink smoothie Extract of malted barley and rice barley and/or barley , milk solids , sugar, cocoa, thickeners (1442, 1440) , oligofructose (dietary fibre), oat bran (5.5%) , inulin (dietary fibre), mineral salts (341, 504, 500), emulsifier (lecithin) , flavours , vitamins [ascorbic acid (vitamin C), retinyl acetate (vitamin A), thiamine hydrochloride (vitamin B1), riboflavin (vitamin B2)], mineral [ferric pyrophosphate (iron)].	Chocolate drink mix Extract of malted barley and rice and/or barley , milk solids , sugar, cocoa, mineral salts (341, 504, 500), flavours , vitamins [ascorbic acid (vitamin C), retinyl acetate (vitamin A), thiamine hydrochloride (vitamin B1), riboflavin (vitamin B2)], mineral [ferric pyrophosphate (iron)], emulsifier (soy lecithin) .	Chocolate drink smoothie Extract of malted barley and rice barley and/or barley , milk solids , sugar, cocoa, thickeners (1442, 1440) , oligofructose (dietary fibre), oat bran (5.5%) , inulin (dietary fibre), mineral salts (341, 504, 500), emulsifier (lecithin) , flavours , vitamins [ascorbic acid (vitamin C), retinyl acetate (vitamin A), thiamine hydrochloride (vitamin B1), riboflavin (vitamin B2)], mineral [ferric pyrophosphate (iron)].
Sugar Granulated Crystallised Sucrose.	Sauce, chilli, sweet Water, tomato Paste (Hot Break), Glucose, Sugar, Salt, Modified Starch , White Vinegar, Citric Acid, Pectin, Acetic Acid, Preservative E202, Ketchup Spice Blend, Ascorbic Acid, Calcium Chloride	Instant coffee Spray Dried Coffee Powder
Salt Sodium Chloride, Anti Caking Agent.	Pepper black Ground dried immature Piper Nigrum Berries.	Sweetened condensed milk Whole Milk Solids , Sugar, Water.

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Appendix F: Nutrient Content of 72 hour LWED CR Menu

Table F1 Detailed breakdown of the daily nutrient provisions

	fat-total (g)	fat-sat [#] (g)	protein (g)	CHO (g)	sugar (g)	energy (kJ)	fibre (g)	sodium (mg)
<i>Day 1</i>								
Slice, apple strawberry	1.9	0.9	7.7	51.5	19.9	1107	7.2	306
Sports drink powder, mixed berry	0.0	0.0	0.0	68.2	67.6	1158	-	220
SPC, orange	0.0	0.0	0.0	24.1	21.3	392	-	60
Peanuts/sultanas mix	19.9	2.4	13.0	37.4	33.2	1649	6.5	336
Steak bar, teriyaki	0.45	0.0	12.5	4.5	4.5	300	-	430
Ration chocolate	14.4	9.8	3.8	28.6	17.8	1090	0.9	40
Gel, apple cinnamon	0.0	0.0	0.0	27.0	2.9	459	-	50
BBQ chicken	6.3	1.0	26.0	22.0	12.0	1048	-	950
Flour tortilla	4.8	2.4	4.0	26.6	2.0	708	-	280
Salt	0.0	-	0.0	0.0	-	0	-	497
Pepper	0.0	-	0.1	0.6	-	11	-	-
Chocolate smoothie	3.0	1.8	3.5	22.8	11.5	585	3.3	50
Sugar	0.0	-	0.0	7.0	7.0	112	-	-
Coffee	0.0	-	0.7	2.4	-	21	-	0
Tea bag	0.0	-	0.0	0.0	-	0	-	-
Sweetened condensed milk	2.3	1.5	2.0	15.9	15.9	397	0.0	33
Total	52.9	19.7	73.4	346.6	215.5	9035	17.8	3251
<i>Day 2</i>								
Food bar, apple	3.0	0.5	10.0	39.0	22.0	924	2.0	30
Sports drink powder, lemon/lime	0.0	0.0	0.0	68.3	58.3	1166	-	225
HPFC	2.6	2.3	0.0	54.4	45.4	1008	-	9
Peanuts/apricots mix	20.0	2.5	12.7	29.1	21.6	1393	3.5	324
Ration chocolate	14.4	9.8	3.8	28.6	17.8	1090	0.9	40
Beef jerky, original	1.8	0.8	12.0	1.8	1.8	297	-	575
Gel, chocolate	1.5	1.0	0.3	28.0	10.0	537	-	200
Tuna with dried tomato	0.8	0.3	17.8	1.7	0.7	360	-	335
Biscuit, savoury	3.8	0.0	5.3	28.6	0.0	718	3.7	181
Sweet chilli sauce	0.0	0.0	0.1	6.7	6.6	116	-	45
Salt	0.0	-	0.0	0.0	-	0	-	497
Pepper	0.0	-	0.1	0.6	-	11	-	-
Chocolate drink	2.5	1.8	3.3	17.6	11.6	455	1.0	45
Sugar	0.0	-	0.0	7.0	7.0	112	-	-
Coffee	0.0	-	0.7	2.4	-	21	-	0
Tea bag	0.0	-	0.0	0.0	-	0	-	-
Sweetened condensed milk	2.3	1.5	2.0	15.9	15.9	397	0.0	33
Total	52.7	20.4	68.1	330.6	218.7	8604	11.1	2538

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	fat-total (g)	fat-sat [#] (g)	protein (g)	CHO (g)	sugar (g)	energy (kJ)	fibre (g)	sodium (mg)
<i>Day 3</i>								
Food bar, strawberry	6.3	1.5	13.8	28.9	16.1	958	-	175
Sports drink powder, tropical	0.0	0.0	0.0	68.5	66.4	1164	-	220
SPC, lemon lime	0.0	0.0	0.0	24	19	389	-	60
Sultanas	0.0	0.0	1.4	32.6	31.6	669	3.0	23
Banana chips	11.0	9.7	0.6	26.4	12.4	868	0.2	8
Food bar, chocolate	3.3	1.7	17.5	34.5	11.3	1001	-	111
Gel, vanilla	<0.1	0.0	<0.1	26.0	10.3	444		36.5
Chilli con carne	16.8	7.6	24.3	26.0	5.5	1513		163
Flour tortilla	4.8	2.4	4.0	26.6	2.0	708		280
Salt	0.0	-	0.0	0.0	-	0	-	497
Pepper	0.0	-	0.1	0.6	-	11	-	-
Chocolate smoothie	3.0	1.8	3.5	22.8	11.5	585	3.3	50
Sugar	0.0	-	0.0	7.0	7.0	112	-	-
Coffee	0.0	-	0.7	2.4	-	21	-	0
Tea bag	0.0	-	0.0	0.0	-	0	-	-
Sweetened condensed milk	2.3	1.5	2.0	15.9	15.9	397	0.0	33
Total	47.5	26.1	67.9	342	209	8838	6.5	1655

[#] *saturated*

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Appendix G: Descriptive Statistics for Acceptability, Portion Size and Percent Consumption

Table G1 Descriptive statistics for acceptability, serve size and consumption of individual food components

Component	scale ¹	outliers		Test of normality: Shapiro-			Non-parametric test:			One-sample 2-sided t-test							Target achieved	Reasoning (if not)
		1.5 SD ²	extreme	Statistic	df ³	Sig ⁴	Null hypoth	Median	Sig ⁴	Mean	SD ²	Test value	Sig ⁴	mean diff	95%-lower	95%-upper		
Apple/strawberry slice	L	-	-	0.866	34	0.001	Median=3	4	0.324	3.24	1.30	3	0.3	0.235	0.22	0.69	Achieved	
	A	-	6 of	0.655	33	0.000	Median=2	2	0.157	2.12	0.49	2	0.16	0.121	0.05	0.29	Achieved	
	C	-	2 of	0.255	34	0.000	Median=0.9	1.0	0.000	0.971	0.119	0.9	0.002	0.071	0.03	0.11	Achieved	
Apple bar	L	2 of	-	0.827	33	0.000	Median=3	4	0.017	3.48	1.03	3	0.011	0.485	0.12	0.85	Achieved	
	A	-	-	0.728	33	0.000	Median=2	2	0.021	2.24	0.56	2	0.018	0.242	0.04	0.44	Not achieved	Not enough provided
	C	-	2 of	0.257	33	0.000	Median=0.9	1.0	0.000	0.955	0.162	0.9	0.113	0.055	0.01	0.12	Achieved	
Chocolate bar	L	4 of	-	0.806	33	0.000	Median=3	4	0.000	3.94	0.93	3	0.000	0.939	0.61	1.27	Achieved	
	A	-	-	0.764	34	0.000	Median=2	2	0.005	2.35	0.65	2	0.003	0.353	0.13	0.58	Not achieved	Not enough provided
	C	-	1 of	0.184	29	0.000	Median=0.9	1.0	0.000	0.966	0.186	0.9	0.068	0.066	0.01	0.14	Achieved	
Strawberry bar	L	-	10 of	0.788	33	0.000	Median=3	4	0.000	3.82	1.01	3	0.000	0.818	0.46	1.18	Achieved	
	A	-	-	0.694	33	0.000	Median=2	2	0.004	2.30	0.53	2	0.002	0.303	0.12	0.49	Not achieved	Not enough provided
	C	-	1 of	0.184	29	0.000	Median=0.9	1.0	0.000	0.966	0.186	0.9	0.068	0.066	0.00	0.14	Achieved	
Sultana/nuts mix	L	4 of	-	0.774	35	0.000	Median=3	4	0.000	3.94	1.03	3	0.000	0.943	0.59	1.30	Achieved	
	A	-	-	0.732	35	0.000	Median=2	3	0.000	2.46	0.61	2	0.000	0.457	0.25	0.67	Not achieved	Not enough provided
	C	-	2 of	0.287	28	0.000	Median=0.9	1.0	0.000	0.929	0.262	0.9	0.569	0.029	-0.07	0.13	Achieved	
Apricot/nuts mix	L	4 of	-	0.781	35	0.000	Median=3	4	0.000	4.03	0.92	3	0.000	1.029	0.71	1.35	Achieved	
	A	-	-	0.701	35	0.000	Median=2	3	0.000	2.51	0.56	2	0.000	0.514	0.32	0.71	Not achieved	Not enough provided
	C	-	4 of	0.403	31	0.000	Median=0.9	1.0	0.006	0.903	0.271	0.9	0.948	0.003	-0.10	0.10	Achieved	
Sultanas	L	8 of	3 of	0.796	35	0.000	Median=3	4	0.007	3.66	1.24	3	0.003	0.657	0.23	1.08	Achieved	
	A	-	-	0.782	34	0.000	Median=2	2	0.029	2.26	0.67	2	0.027	0.265	0.03	0.50	Not achieved	Not enough provided
	C	-	3 of	0.361	28	0.000	Median=0.9	1.0	0.002	0.893	0.315	0.9	0.905	-0.007	-0.13	0.12	Achieved	
Banana chips	L	-	-	0.831	35	0.000	Median=3	4	0.006	3.66	1.33	3	0.006	0.657	0.20	1.11	Achieved	
	A	-	-	0.8	35	0.000	Median=2	2	0.225	2.14	0.69	2	0.23	0.143	-0.09	0.38	Achieved	
	C	-	5 of	0.494	27	0.000	Median=0.9	1.0	0.1	0.870	0.297	0.9	0.609	-0.030	-0.15	0.09	Achieved	
Steak bar, teriyaki	L	-	4 of	0.366	35	0.000	Median=3	5	0.000	4.69	0.96	3	0.000	1.686	1.35	2.02	Achieved	
	A	-	3 of	0.324	34	0.000	Median=2	3	0.000	2.88	0.41	2	0.000	0.882	0.74	1.03	Not achieved	Not enough provided
	C	-	-	N/A	N/A	N/A	Median=0.9	1.0	0.000	1.000	0.000	0.9	0.000	0.000	0.00	0.00	Achieved	
Beef jerky, original	L	-	5 of	0.389	35	0.000	Median=3	5	0.000	4.74	0.74	3	0.000	1.743	1.49	2.00	Achieved	
	A	-	3 of	0.318	35	0.000	Median=2	3	0.000	2.89	0.40	2	0.000	0.886	0.75	1.02	Not achieved	Not enough provided
	C	-	-	N/A	N/A	N/A	Median=0.9	1.0	0.000	1.000	0.000	0.9	0.000	0.000	0.00	0.00	Achieved	
Soft panned confectionery orange	L	-	-	0.667	35	0.000	Median=3	5	0.000	4.60	0.55	3	0.000	1.600	1.41	1.79	Achieved	
	A	-	-	0.567	35	0.000	Median=2	3	0.000	2.71	0.46	2	0.000	0.714	0.56	0.87	Not achieved	Not enough provided
	C	-	-	N/A	N/A	N/A	Median=0.9	1.0	0.000	1.000	0.000	0.9	0.000	0.000	0.00	0.00	Achieved	
Soft panned confectionery lemon/lime	L	-	-	0.667	35	0.000	Median=3	5	0.000	4.60	0.55	3	0.000	1.600	1.41	1.79	Achieved	
	A	-	-	0.567	35	0.000	Median=2	3	0.002	2.71	0.46	2	0.000	0.714	0.56	0.87	Not achieved	Not enough provided
	C	-	-	N/A	N/A	N/A	Median=0.9	1.0	0.000	1.000	0.000	0.9	0.000	0.000	0.00	0.00	Achieved	

Table G1cont.d Descriptive statistics for acceptability, serve size and consumption of individual food components

Component	scale ¹	outliers		Test of normality: Shapiro			Non-parametric test:			One-sample 2-sided t-test							Target achieved	Reasoning (if not)
		1.5 SD ²	extreme	Statistic	df ³	Sig ⁴	Null hypoth	Median	Sig ⁴	Mean	SD ²	Test value	Sig ⁴	mean diff	95%-lower	95%-upper		
Hard panned fruit	L	2 of	-	0.726	35	0.000	Median=3	4	0.000	4.29	0.89	3	0.000	1.288	0.98	1.59	Achieved	
confectionery	A	-	-	0.711	35	0.000	Median=2	2	0.000	2.46	0.56	2	0.000	0.457	0.26	0.65	Not achieved	Not enough provided
	C	-	1 of	0.180	30	0.000	Median=0.9	1.0	0.000	0.983	0.091	0.9	0.000	0.083	0.05	0.12	Achieved	
Ration chocolate	L	-	-	0.866	35	0.001	Median=3	2	0.499	2.83	1.47	3	0.493	-0.171	-0.67	0.33	Achieved	
	A	-	-	0.811	33	0.000	Median=2	2	0.808	1.97	0.73	2	0.813	-0.030	-0.29	0.23	Achieved	
	C	-	4 of	0.427	27	0.000	Median=0.9	1.0	0.024	0.852	0.362	0.9	0.496	-0.048	-0.19	0.10	Achieved	
BBQ chicken	L	-	-	0.776	35	0.000	Median=3	4	0.108	3.40	1.27	3	0.070	0.400	-0.03	0.83	Achieved	
	A	-	-	0.742	34	0.000	Median=2	2	0.083	2.18	0.58	2	0.083	0.176	-0.02	0.38	Achieved	
	C	-	4 of	0.445	32	0.000	Median=0.9	1.0	0.021	0.875	0.311	0.9	0.653	-0.025	-0.14	0.09	Achieved	
Tuna with dried tomato	L	4 of	-	0.661	34	0.000	Median=3	5	0.000	4.35	0.98	3	0.000	1.353	1.01	1.70	Achieved	
	A	-	-	0.590	34	0.000	Median=2	3	0.000	2.71	0.52	2	0.000	0.706	0.52	0.89	Not achieved	Not enough provided
	C	-	-	N/A	N/A	N/A	Median=0.9	1.0	0.000	1.000	0.000	0.9	0.000	0.000	0.00	0.00	Achieved	
Chilli con carne	L	2 of	-	0.776	34	0.000	Median=3	4	0.000	4.09	0.87	3	0.000	1.088	-0.05	1.39	Achieved	
	A	-	-	0.633	34	0.000	Median=2	2	0.000	2.44	0.50	2	0.000	0.441	0.27	0.62	Not achieved	Not enough provided
	C	-	4 of	0.415	29	0.000	Median=0.9	1.0	0.012	0.879	0.318	0.9	0.729	-0.021	-0.01	0.10	Achieved	
Flour tortilla	L	2 of	-	0.708	35	0.000	Median=3	5	0.000	4.34	0.94	3	0.000	1.343	1.02	1.66	Achieved	
	A	-	4 of	0.378	34	0.000	Median=2	3	0.000	2.88	0.33	2	0.000	0.862	0.77	1.00	Not achieved	Not enough provided
day 1	C	-	2 of	0.259	33	0.000	Median=0.9	1.0	0.000	0.939	0.242	0.9	0.357	0.039	-0.05	0.13	Achieved	
day 3	C	-	1 of	0.188	28	0.000	Median=0.9	1.0	0.000	0.964	0.187	0.9	0.083	0.064	-0.01	0.14	Achieved	
Biscuit, savoury	L	1 of	-	0.646	35	0.000	Median=3	5	0.000	4.54	0.66	3	0.000	1.543	1.22	1.77	Achieved	
	A	-	-	0.606	34	0.000	Median=2	3	0.000	2.65	0.49	2	0.000	0.647	0.48	0.82	Not achieved	Not enough provided
	C	-	1 of	0.165	34	0.000	Median=0.9	1.0	0.000	0.971	0.172	0.9	0.022	0.071	0.01	0.13	Achieved	
Sauce, sweet chilli	L	-	-	0.863	33	0.001	Median=3	4	0.000	3.79	0.82	3	0.000	0.788	0.50	1.08	Achieved	
	A	-	4 of	0.492	30	0.000	Median=2	2	0.014	2.20	0.41	2	0.012	0.200	0.05	0.35	Achieved	
	C	-	-	0.579	33	0.000	Median=0.9	0.0	0.000	0.303	0.467	0.9	0.000	-0.597	-0.76	-0.43	Not achieved	Not enough consumed
Gel, apple cinnamon	L	-	-	0.847	35	0.000	Median=3	4	0.671	3.11	1.28	3	0.6	0.114	-0.32	0.55	Achieved	
	A	-	-	0.775	34	0.000	Median=2	2	0.109	2.18	0.63	2	0.11	0.176	-0.04	0.39	Achieved	
	C	-	4 of	0.491	31	0.000	Median=0.9	1.0	0.107	0.823	0.377	0.9	0.262	-0.077	-0.22	0.06	Achieved	
Gel, chocolate	L	-	-	0.850	35	0.000	Median=3	2	0.259	2.77	1.31	3	0.309	0.229	-0.68	0.22	Achieved	
	A	-	7 of	0.793	33	0.000	Median=2	2	0.593	2.06	0.66	2	0.601	0.061	-0.17	0.29	Achieved	
	C	-	-	0.656	34	0.000	Median=0.9	1.0	0.431	0.721	0.412	0.9	0.016	-0.179	-0.32	-0.04	Not achieved	Not enough consumed
Gel, vanilla	L	-	-	0.856	34	0.000	Median=3	4	0.48	3.21	1.37	3	0.386	0.206	-0.27	0.68	Achieved	
	A	-	-	0.763	32	0.000	Median=2	2	0.052	2.22	0.61	2	0.051	0.219	0.00	0.44	Achieved	
	C	-	-	0.576	27	0.000	Median=0.9	1.0	0.98	0.704	0.465	0.9	0.038	-0.196	-0.38	-0.01	Not achieved	Not enough consumed
Sports drink, mixed berry	L	-	-	0.865	32	0.001	Median=3	4	0.000	3.88	0.87	3	0.000	0.875	0.56	1.19	Achieved	
	A	-	5 of	0.586	30	0.000	Median=2	2	0.102	2.13	0.43	2	0.103	0.133	-0.03	0.30	Achieved	
	C	-	-	0.654	32	0.000	Median=0.9	1.0	0.033	0.547	0.498	0.9	0.000	-0.353	-0.53	-0.17	Not achieved	Not enough consumed

Table G1cont.d Descriptive statistics for acceptability, serve size and consumption of individual food components

Component	scale ¹	outliers		Test of normality: Shapiro-			Non-parametric test:			One-sample 2-sided t-test							Target achieved	Reasoning (if not)
		1.5 SD ²	extreme	Statistic	df ³	Sig ⁴	Null hypoth	Median	Sig ⁴	Mean	SD ²	Test value	Sig ⁴	mean diff	95%-lower	95%-upper		
Sports drink, lemon/lime	L	-	-	0.868	33	0.001	Median=3	4	0.000	3.76	0.83	3	0.000	0.758	0.46	-0.29	Achieved	
	A	-	5 of	0.545	30	0.000	Median=2	2	0.180	2.10	0.40	2	0.184	0.100	-0.05	0.25	Achieved	
	C	-	-	0.671	32	0.000	Median=0.9	0.0	0.001	0.438	0.488	0.9	0.000	-0.463	-0.64	-0.29	Not achieved	Not enough consumed
Sports drink, tropical	L	-	-	0.858	32	0.001	Median=3	4	0.000	3.67	0.81	3	0.000	0.844	0.55	1.13	Achieved	
	A	-	5 of	0.536	31	0.000	Median=2	2	0.180	2.10	0.40	2	0.184	0.097	-0.05	0.24	Achieved	
	C	-	-	0.602	29	0.000	Median=0.9	0.0	0.000	0.345	0.484	0.9	0.000	-0.555	-0.74	-0.37	Not achieved	Not enough consumed
Chocolate drink mix	L	-	-	0.849	35	0.000	Median=3	4	0.021	3.60	1.36	3	0.013	0.600	0.13	1.07	Achieved	
	A	-	-	0.760	31	0.000	Median=2	2	0.083	2.19	0.60	2	0.083	0.194	-0.03	0.41	Achieved	
	day 1	C	-	0.499	30	0.000	Median=0.9	1.0	0.138	0.817	0.382	0.9	0.242	-0.083	-0.23	0.06	Achieved	
Coffee, instant	day 2	C	-	0.340	31	0.000	Median=0.9	1.0	0.001	0.903	0.301	0.9	0.953	-0.003	-0.11	0.11	Achieved	
	day 3	C	-	0.541	28	0.000	Median=0.9	1.0	0.501	0.750	0.441	0.9	0.083	-0.150	-0.32	0.02	Not achieved	
	L	1 of	-	0.793	34	0.000	Median=3	4	0.000	4.15	0.96	3	0.000	1.147	0.81	1.48	Achieved	
Tea, bag	A	-	-	0.635	33	0.000	Median=2	3	0.000	2.55	0.51	2	0.000	0.545	0.37	0.72	Not achieved	Not enough provided
	C	-	-	0.877	32	0.002	Median=0.9	0.667	0.001	0.584	0.502	0.9	0.001				Not achieved	Not enough consumed
	L	-	-	0.867	34	0.001	Median=3	3.5	0.001	3.62	0.92	3	0.000	0.618	0.30	0.94	Achieved	
Sweetened cond. milk	A	-	-	0.754	32	0.000	Median=2	2	0.083	2.19	0.59	2	0.083	0.188	-0.03	0.40	Achieved	
	C	1 of	-	0.741	31	0.000	Median=0.9	0	0.000	0.312	0.394	0.9	0.000				Not achieved	Not enough consumed
	L	-	-	0.827	35	0.000	Median=3	4	0.000	4.14	0.81	3	0.000	1.143	0.86	1.42	Achieved	
Sugar	A	-	-	0.621	33	0.000	Median=2	3	0.000	2.61	0.50	2	0.000	0.606	0.43	0.78	Not achieved	Not enough provided
	C	-	-	0.612	28	0.000	Median=0.9	1	0.867	0.804	0.343	0.9	0.148				Achieved	
	L	-	-	0.784	34	0.000	Median=3	4	0.000	3.88	0.64	3	0.000	0.882	0.66	1.11	Achieved	
Salt	A	1 of	-	0.694	31	0.000	Median=2	2	0.007	2.29	0.53	2	0.005	0.290	0.10	0.48	Not achieved	Not enough provided
	C	-	-	0.900	32	0.006	Median=0.9	0.667	0.000	0.532	0.381	0.9	0.000				Not achieved	Not enough consumed
	L	-	4 of	0.806	33	0.000	Median=3	4	0.000	3.64	0.65	3	0.000	0.360	0.40	0.87	Achieved	
Pepper	A	-	3 of	0.505	29	0.000	Median=2	2	0.317	2.07	0.37	2	0.326	0.069	-0.07	0.21	Achieved	
	C	-	-	0.358	29	0.000	Median=0.9	0	0.000	0.069	0.221	0.9	0.000				Not achieved	Not enough consumed
	L	-	-	0.843	33	0.000	Median=3	4	0.000	3.64	0.74	3	0.000	0.636	0.37	0.90	Achieved	
Pepper	A	-	5 of	0.545	30	0.000	Median=2	2	0.18	2.10	0.40	2	0.184	0.100	-0.05	0.25	Achieved	
	C	-	4 of	0.382	31	0.000	Median=0.9	0	0.000	0.089	0.263	0.9	0.000				Not achieved	Not enough consumed
N/A values could not be computed as response was constant.				Normal distribution, p>0.05			Retain null hypothesis, p>0.05							Significant (p<0.05), Achieved/Not achieved				
				Not normal distribution, p<0.05			Reject null hypothesis, p<0.05							Highly significant (p<0.002), Achieved/Not achieved				
														Not significantly different, p>0.05				

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Table G2 *Descriptive statistics for acceptability and amount provided of non-food items*

Component	scale	outliers		Test of normality-Shapiro-			Non-parametric test-Wilcoxon			One-sample t-test							Target achieved	Reasoning (if not)
		1.5 SD	extreme	Statistic	df	Sig	Null hypoth	Median	Sig.	Mean	Stdev	Test value	Sig.	mean diff	95%-lower	95%-upper		
Spoon	L	-	-	0.681	35	0.000	Median=3	5	0.000	4.57	0.56	3	0.000	1.571	1.38	1.76	Achieved	
	A	-	2 of	0.265	32	0.000	Median=2	2	0.157	2.06	0.25	2	0.161	0.063	-0.03	0.15	Achieved	
Matches, waterproof	L	-	-	0.823	34	0.000	Median=3	4	0.003	3.76	1.13	3	0.000	0.765	0.37	1.16	Achieved	
	A	-	5 of	0.553	32	0.000	Median=2	2	0.655	2.03	0.40	2	0.662	0.031	-0.11	0.18	Achieved	
Matches, box	L	4 of	-	0.866	34	0.001	Median=3	4	0.221	3.32	1.25	3	0.140	0.324	-0.11	0.76	Achieved	
	A	-	4 of	0.404	30	0.000	Median=2	2	0.048	1.87	0.35	2	0.043	-0.133	-0.26	0.00	Not achieved	Too much provided
Pads, Scouring	L	2 of	-	0.865	34	0.001	Median=3	3	0.288	3.18	0.90	3	0.263	0.175	-0.14	0.49	Achieved	
	A	-	4 of	0.452	30	0.000	Median=2	2	0.025	1.83	0.38	2	0.023	-0.167	-0.31	-0.03	Not achieved	Too much provided
Rubber bands	L	-	-	0.792	34	0.000	Median=3	4	0.000	3.76	0.70	3	0.000	0.765	0.52	1.01	Achieved	
	A	-	5 of	0.568	32	0.000	Median=2	2	0.102	2.13	0.42	2	0.103	0.125	-0.03	0.28	Achieved	
Toilet Paper	L	-	-	0.800	34	0.000	Median=3	4	0.000	4.18	0.72	3	0.000	1.176	0.93	1.43	Achieved	
	A	-	6 of	0.687	32	0.000	Median=2	2	0.096	2.16	0.52	2	0.096	0.156	-0.03	0.34	Achieved	
Bags, resealable	L	1 of	-	0.808	34	0.000	Median=3	4	0.000	4.15	0.74	3	0.000	1.147	0.89	1.41	Achieved	
	A	-	-	0.602	32	0.000	Median=2	2	0.001	2.34	0.48	2	0.000	0.344	0.17	0.52	Not achieved	Not enough provided
				Normal distribution, p>0.05				Retain null hypothesis, p>0.05						Significant (p<0.05), Achieved/Not achieved				
				Not normal distribution, p<0.05				Reject null hypothesis, p<0.05						Highly significant (p<0.002), Achieved/Not achieved				
														Not significantly different, p>0.005				

Notes

- 1 L - Likeability, A - amount provided, C - consumption
- 2 SD - standard deviation
- 3 df - degrees of freedom
- 4 Sig - level of significance

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19. ABSTRACT Many of today's military operations demand a combat ration (CR) that is smaller, lighter and more readily consumed than the current capability can deliver. DSTO-Scottsdale has developed and evaluated a prototype energy-dense, nutrient-optimised CR to sustain land forces undertaking arduous activities over a 72 hour period. A prototype pack was assembled after integrating user requirements, nutritional requirements and other design considerations. This CR was field tested at Exercise Talisman Sabre to assess user acceptability, consumption patterns and service suitability. Shelf life testing was then conducted on the commercial-of-the-shelf (COTS) food components included in the pack. This study identified a Defence requirement for specialised CR for short-term, high-intensity operations. Army's current CR feeding systems capability will benefit from expanding the scope to deliver lighter, smaller and more readily consumed CR for specific missions of interest to Defence. To improve acceptability, consumption and nutrition of CR, more eat-on-the-move (EOTM) food components need to be included in menu design. Popular COTS food components should be considered, where relevant, as EOTM foods in CR menus.					